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INDUSTRIAL PROTECTION MANUAL.(U)

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SCIENTIFIC  
SERVICE INC

REDWOOD CITY CA

INDUSTRIAL  
PROTECTION  
MANUAL

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June 1981

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# INDUSTRIAL PROTECTION MANUAL



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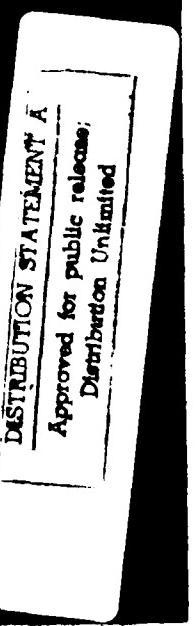
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Work Unit 1124E

SCIENTIFIC SERVICE, INC.

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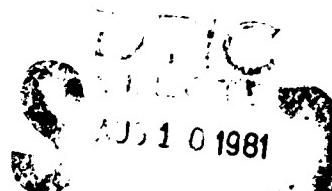


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## CRISIS RELOCATION INDUSTRIAL HARDENING PLAN

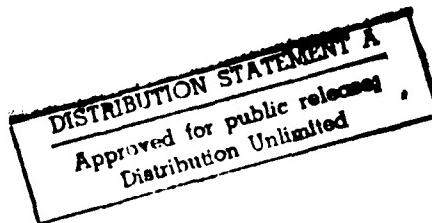
Booklet 1

### MANAGEMENT PLANNING GUIDE



This is one of ten booklets of the Industrial Hardening Manual  
developed for the  
Federal Emergency Management Agency  
under Contract No. EMW-C-0154, Work Unit 1124E

**SCIENTIFIC SERVICE, Inc.**  
Redwood City, California 94063



## PREFACE

A plan to save lives and resources is presented which can be implemented subsequent to a disaster warning in 72 hours, if necessary. The plan presents three major responses:

1. Shutdown of non-essential operations and removal of irreplaceable documents, records, plant equipment, and vehicles to the safety of an emergency relocation site.
2. Preparation of an emergency relocation site to which employees and dependents would be moved during a crisis.
3. Systematic reduction in the vulnerability of plant property and equipment (called hardening).

Response is achieved through a number of different activities detailed in individual booklets.

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Booklet 1

**MANAGEMENT PLANNING GUIDE**

In an emergency situation, disaster planning requires attention to two problems:

- o Plant equipment and plant personnel survival
- o Post-crisis recovery and operation

This guide was developed to help you improve your company's chances for survival and recovery from a disaster. There is special emphasis in the plan on protection from nuclear threats, but many of the actions are applicable to other emergencies as well. Planning and preparation are the most important management steps that can be taken to minimize the impact of any disaster, and temporarily relocating to get out of the path of a disaster is the oldest tested response.

Current emergency preparedness strategy is based on advance warning of a threat because most natural and nuclear disasters provide advance warning. If nuclear, the disaster could be triggered by terrorists or by observation that an unfriendly power was evacuating cities. (The latter case is expected to provide three or more days warning to act.) If a natural disaster, warnings range from several hours to three days (e.g., tornadoes, hurricanes --- eventually even earthquakes may be predictable). Preparedness and crisis relocation are part of the emergency strategy for survival whether a natural or nuclear disaster.

Crisis relocation requires that all non-essential personnel (and everything that may be critical to rapid recovery) be moved out of designated high-risk areas when possible, and dispersed into surrounding lower-risk (host) areas for the duration of the emergency, and that everything that may be critical to rapid recovery be either hardened (protected) in place or also evacuated to low-risk areas.

There are other strategies. For example, underground school facilities in parts of the United States enable operations to continue right through a tornado or an earthquake. This same strategy is employed by the Swedes, Swiss, and the Soviets, who have built underground facilities to enable operations to continue through a nuclear crisis.

Planning for dispersal in a crisis, Crisis Relocation Planning (CRP), is being conducted at the Federal and State levels. The intent of this manual is to provide an approach that is compatible with the relocation strategy for industry to use to protect production equipment in the face of an impending crisis. Saving production equipment in addition to lives is important because production capability is critical to survival after recovery. By using advance planning, response time can be shortened so that sufficient time is available for emergency shutdown of operations and for completion of tasks that will limit the risk to equipment and facilities left behind. Early planning will enable you to marshall your resources quickly in an emergency to do this job. The underlying rationale for crisis relocation (or for location of facilities underground) is described below.

Figures 1 and 2 give a generalized picture of the immediate effects around the worst disaster, a nuclear burst; two sizes of weapon are shown. With hardening, even though most buildings inside the two rings marked with arrows would be badly damaged or demolished, protected equipment could survive outside the two rings marked X. It is estimated that with no civil defense a massive attack including many thousands of weapons such as the one shown in Figure 2 would destroy a majority of the industrial base of the country. With a viable and implemented industrial protection plan it is estimated that most of the industrial base would survive. This is more apparent in Figure 3.

In order for such a plan to work, it must have the full cooperation of industry, and industry management must realize that only by their actions can their livelihood be preserved.

The plan presented in this manual is relatively simple to implement and is designed so that much of the planning and preparation can be done far in advance.

Figure 1. DIRECT EFFECTS OF 1 MT. BLAST  
(SURFACE BURST)

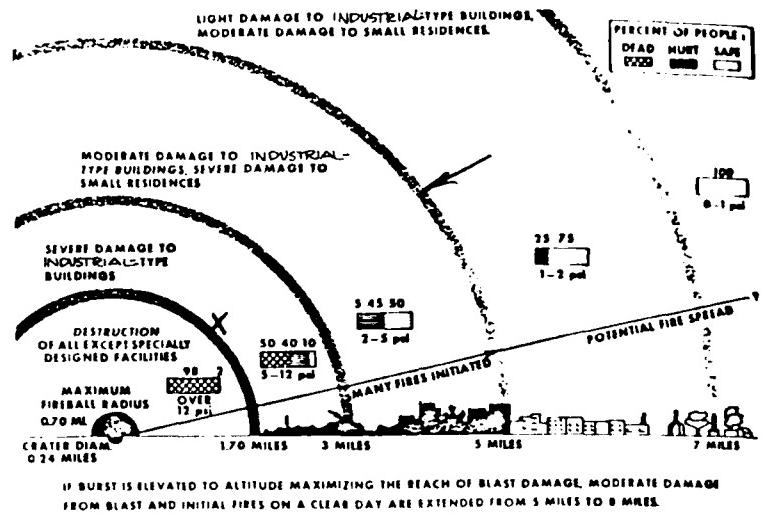
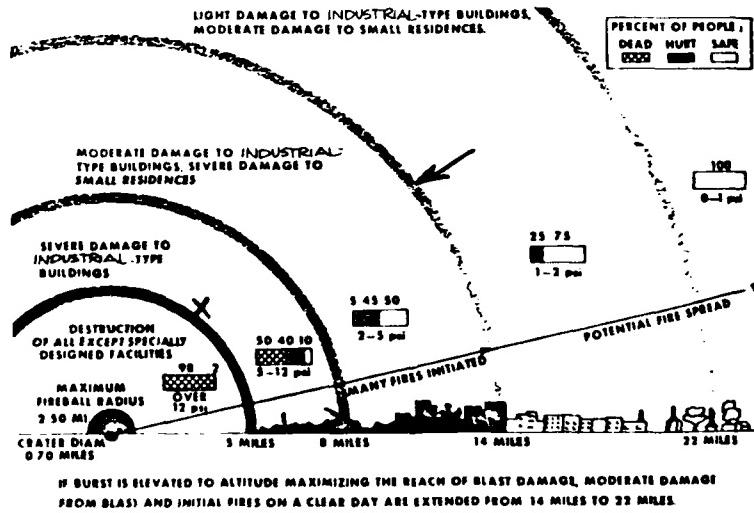
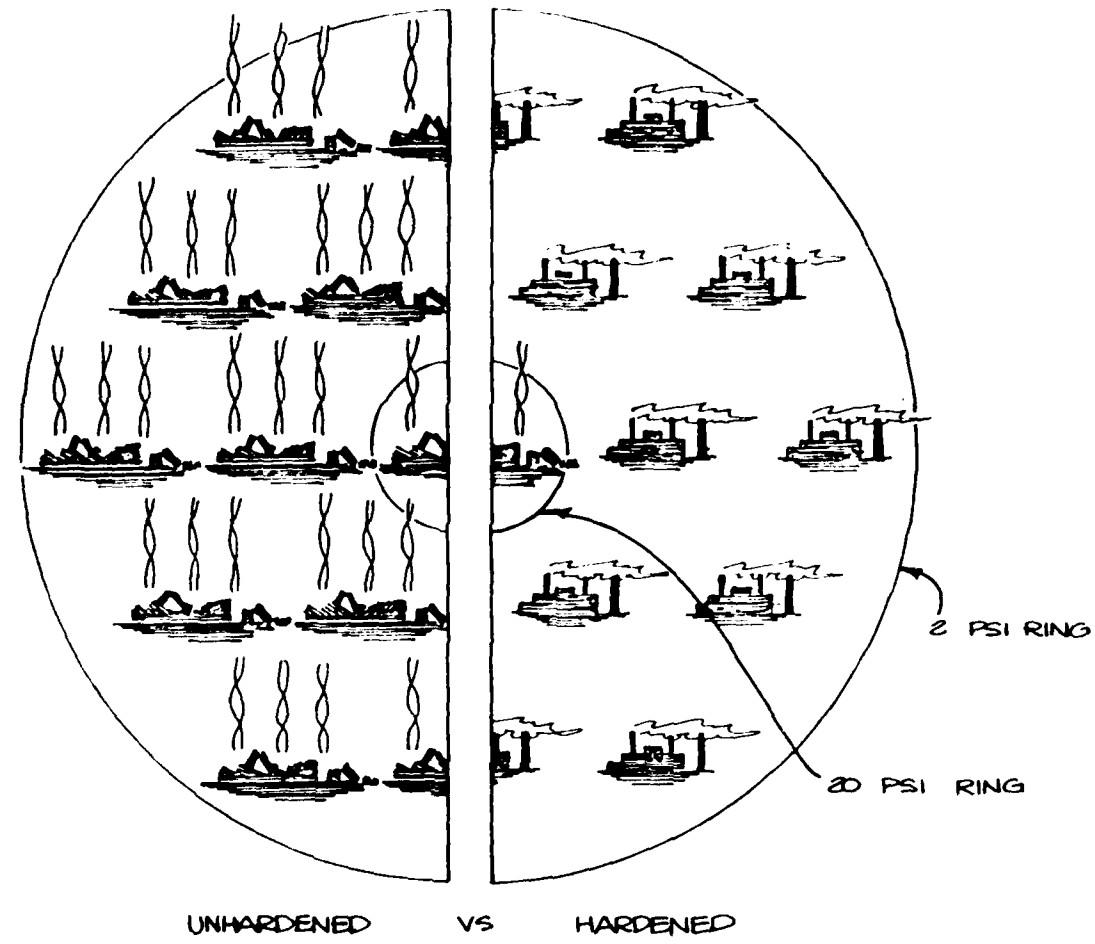


Figure 2. DIRECT EFFECTS OF 25 MT. BLAST  
(SURFACE BURST)





NOTE: PLANT SYMBOLS REPRESENT DAMAGE EXPECTED OF PRODUCTION EQUIPMENT.

Fig. 3. Relative Impact of a Nuclear Attack on Production for Hardened versus Unhardened Equipment.

The plan also allows for rapid implementation in time of crisis, and for the most part is designed to use the personnel and material resources at hand. The plan, called Industrial Hardening, is presented in 10 booklets, which make up the current manual. It is expected that the overall manual will be improved on a regular basis; it can also be applied to advantage now. The various activities involved in implementing the plan are shown in Figure 4.

Industrial Hardening is anything that will reduce the vulnerability of plant or plant equipment to nuclear weapons effects (which include fire, ground motions, hurricane winds, pressure waves, electromagnetic pulse, fallout) or natural disasters. It must be done before final evacuation, and will generally require a lot of people. Your employees will be more likely to be responsive to this task if both they and you have discussed it and planned ahead. Also, if their dependents are reasonably safe and you are certain about your decisions, the hardening is considerably more likely to get done. If the warning to evacuate is given and your employees' dependents are still in the high-risk areas, they will have little difficulty choosing between saving family and saving equipment. But, if they know that in such an event their plant has an emergency plan that considers the problem and prepares for it, this may help you retain the cooperation that will be needed for the hardening effort. Plans for protecting personnel are described in two of the booklets.

Not only manpower, but material and equipment resources must be committed to conduct the tasks required to complete plant hardening activities. Whether planning is done early or late, your response requires consideration of the same factors; hardening requires assessment of options, thoughtful decisions, and completion of task assignments on a schedule. If the planning is done early, much more will be accomplished. Planning should encompass the following factors:

- o Priorities for hardening equipment so that personnel, materials, equipment resources can be committed to produce the optimum result in the time available.

CRISIS RELOCATION INDUSTRIAL HARDENING PLAN

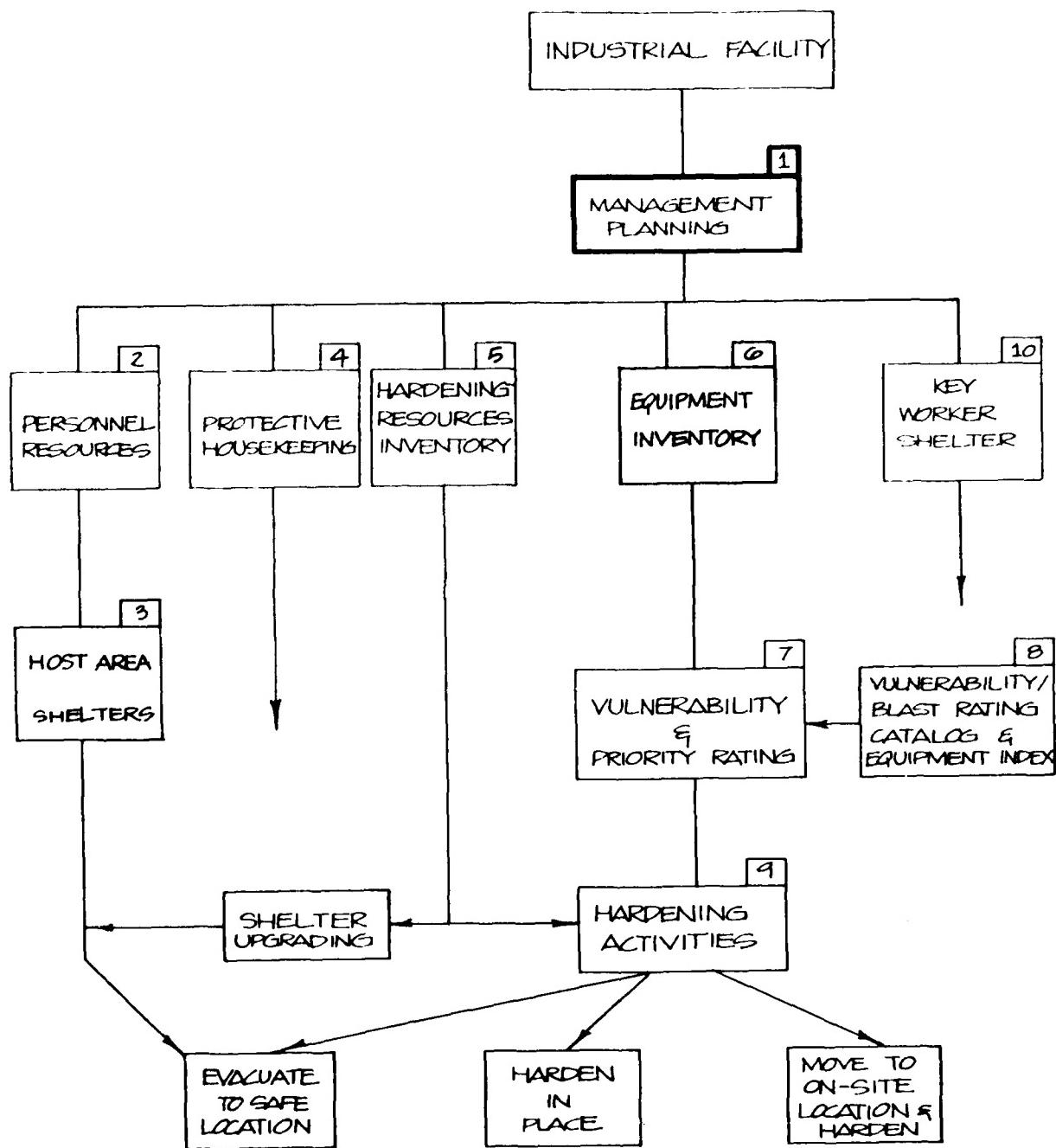


Fig. 4 Crisis Relocation Industrial Hardening Plan.

- o Consideration and establishment of a fallback position (i.e., less production, lower quality, or both) if necessary, to set workable priorities for hardening activities that can be completed:

What simpler, alternative production processes might be used, post-disaster, that would simplify hardening?

What items are absolutely essential (critical to production whatever the process)?

What are the relative importances of the remaining (less critical) items?

- o Options to reduce specific vulnerability of priority equipment:

Evacuate to host area

Move to safer location in plant and harden

Harden in place

- o Completion of inventory lists of priority equipment indicating those to be evacuated, those to be moved and hardened, those to be hardened in place, and those to be abandoned.

- o Decision as to specific actions to accomplish objectives, with resources allocated to task.

- o Options to reduce general plant vulnerability when evacuation of equipment is impossible or incomplete. These options involve -- extensive plant cleanup to remove combustible materials, fragile equipment, loose objects; disconnection of electrical equipment from power lines; installation of standby power supplies in hardenable underground structures (with separate fuel supply also underground); neutralization of the risk from hazardous materials on site; etc. These options are described in the Plant Protective Housekeeping Booklet. Protective housekeeping appears to be the most cost effective measure

known to reduce vulnerability to equipment left onsite and to limit damage caused to neighboring plants. Current benefits are reduction in fire hazard, better plant safety records, safer hazardous materials storage, better preparation for power outages.

Booklets and worksheets that can assist management in organizing the planning, decision processes, and task assignments have been provided. Brief descriptions of each follow, so that assignments can be made. The last page of this booklet can be filled in to provide a record of the assignments.

**PERSONNEL RESOURCES, Booklet 2.** Maintain an effective industrial unit by developing employees and their dependents into an efficient survival team to improve security of plant personnel and equipment. Tasks here are:

- 1) To develop a roster of personnel that will be available.
- 2) To develop a procedure to help employees shut down households and arrange dependents' evacuation efficiently, rapidly, systematically, and compatibly with State and local plans (where they exist) to designated low-risk areas, with food and clothing supplies for a minimum of two weeks.
- 3) To develop a list of practical skills available among employees and dependents (e.g., nursing, paramedic, carpentry).
- 4) To develop a list of special provisions that must be prepared (for diabetics, handicapped, etc.).

**HOST AREA SHELTERS, Booklet 3.** Provides design and construction information necessary to establish shelters in the host area for use during the crisis period. Included are both quick-fix converted shelters, and expedient shelters where there is nothing to convert.

**PLANT PROTECTIVE HOUSEKEEPING, Booklet 4.** Develops an approach for implementing protective housekeeping that can reduce the severity of earthquake, hurricane, tornado, and weapons effect damage to equipment left onsite. Fires are the major destructive force in all such large disasters, so onsite combustible materials must be removed or neutralized. To reduce hazards from toxic and hazardous materials during recovery, containers must be protected from rupture or puncture. To reduce damage from electromagnetic pulses, all electrical systems not deliberately functioning must be unplugged from power lines, and antennas disconnected. To reduce puncture and other damage from missiles created by wind forces, loose materials, debris, containers, and vehicles must be relocated (tied down, evacuated, buried).

**HARDENING RESOURCES INVENTORY Booklet, 5.** Leads to a surveyed list of resources available to carry out the various plan elements that might be developed to harden the facility and to return it rapidly to production after the crisis is over. Hardening alternatives involve the movement of personnel, records, equipment to low-risk (non-target) areas; construction of revetments, berms, burial pits for equipment; lashing down packaged and cushioned equipment with cable, rope, chain link fencing and/or burying it; disassembly of vulnerable structures, etc. Returning the facility to production will require salvage tools, including winches, cranes, materials handling equipment, which may no longer be available (accessible), if left onsite. These resources are best evacuated to the host area so they will be in your hands when you are ready for them.

**EQUIPMENT INVENTORY, Booklet 6.** Leads to a list of plant equipment organized to establish hardening priorities. There may be a limit to the plant equipment that you will be able to protect with the time, materials, equipment, and personnel available. There are a number of approaches that can simplify this task. For example, suppose there is a great deal of redundancy in production equipment and processes at your plant. Redundancy provides the simplest means for establishing priorities: hardening activities can be planned around less

capacity and longer hours; e.g., consider a single shift production line including 4 punch presses, 6 drill presses, and 2 riveting machines (then evacuate or harden one combination of 2 punch presses, 3 drill presses, and 1 riveting machine and operate the other set with two shifts). If there is so little redundancy (or you already operate three shifts) that this option is not practical and there is not sufficient time, materials, or personnel to accomplish the hardening, then a plan may have to be established for alternative methods of production (requiring less equipment) so that you can salvage enough equipment to return to production without any serious bottlenecks. Should no simple concept (such as the two examples) present itself to guide your decision regarding hardening, then a quantitative method has been provided in Booklets 6 through 8.

**VULNERABILITY/PRIORITY RATING & HARDENING DECISIONS, Booklet 7.**

Provides approaches to setting priorities. The aim is a methodology to define, systematically, the relative importance to production of each item of equipment. Vulnerability and importance are combined in a single rating to provide the basis for ranking the order in which hardening activities can deliver the greatest overall reduction in plant vulnerability, based on your assignment of relative importance to operations and relative vulnerability of equipment in your plant. Plant personnel assigned to this task should have the ability to recognize alternative production methods that can be used in emergencies to maintain some production when there is damaged or inoperative equipment.

**VULNERABILITY/BLAST RATINGS CATALOG & EQUIPMENT INDEX, Booklet 8.**

Supplements to the Vulnerability/Priority Rating & Hardening Decisions booklet needed to accomplish tasks defined in Booklet 7.

**HARDENING ALTERNATIVES, Booklet 9.** A catalog of equipment hardening options. Categories available are:

- 1) Evacuate to a safe area;
- 2) Harden in place;
- 3) Relocate onsite to a safer location where hardening is simpler.

Sketches depicting ideas for hardening alternatives are furnished (see examples at the end of this booklet) to provide insight into the process.

**KEY WORKER SHELTER, Booklet 10.** Provides design and construction information necessary to establish shelters onsite at plants that will operate through the crisis with a skeleton crew.

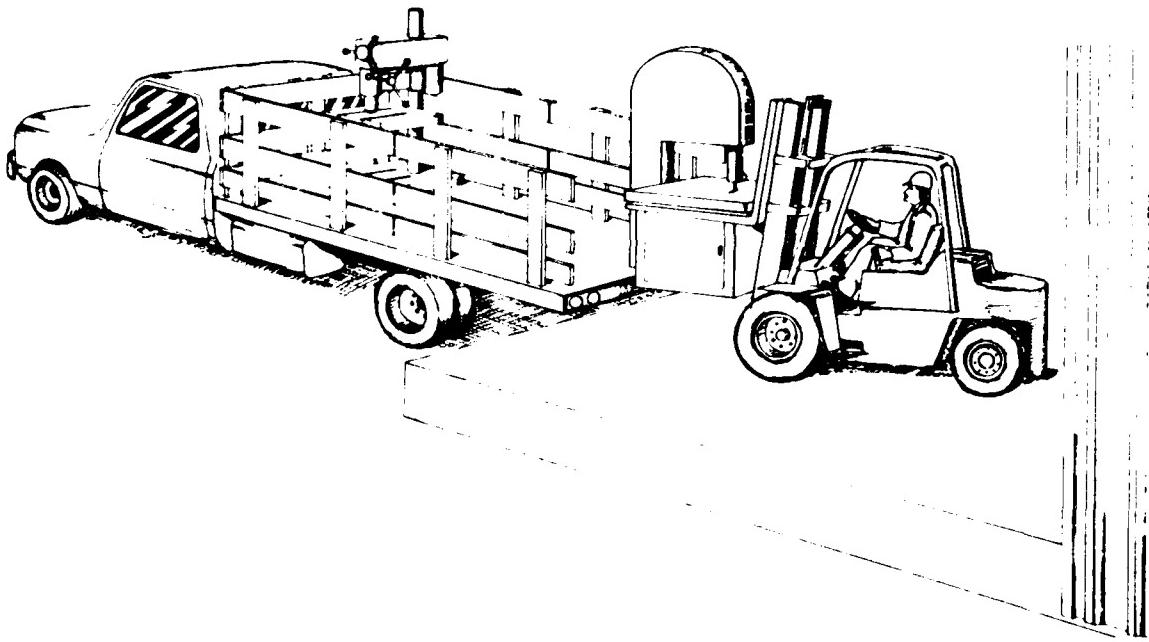
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A major post-attack problem at every plant will be the availability of utilities -- particularly electrical and gas utilities. Where plants are equipped with standby oil-fired systems and underground fuel tanks, they will be able to resume operations more rapidly in emergencies that damage utility power plants, particularly if special effort is taken to harden the standby systems. Those plants that generate their own electricity while producing process heat will be the least vulnerable, whatever the emergency, if they take advance precautions to harden their generating facility.

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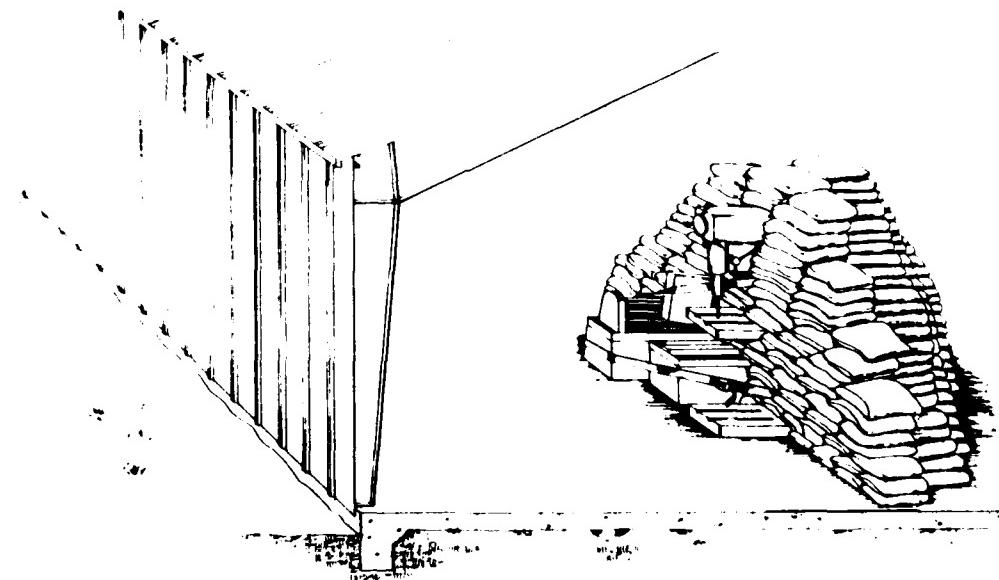
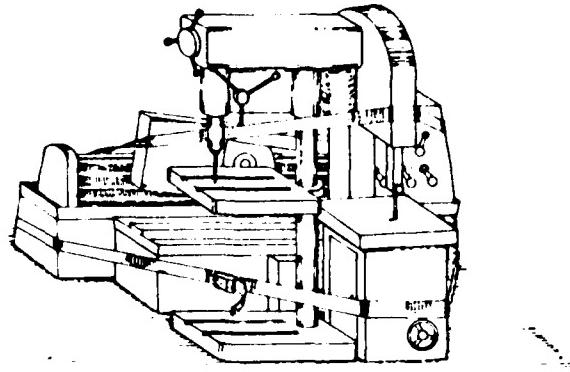
The following sketches identify general hardening techniques that can be applied to protect equipment.

TO SAVE YOUR EQUIPMENT



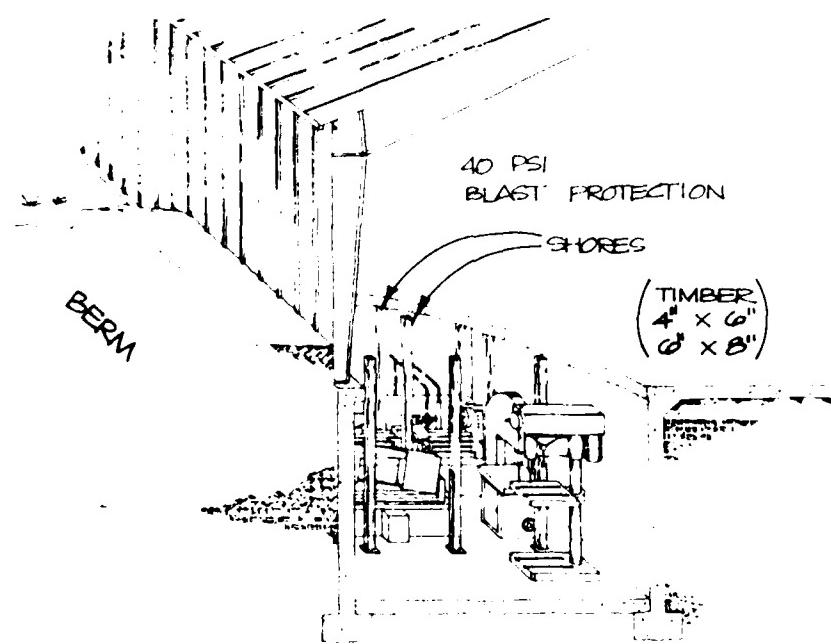
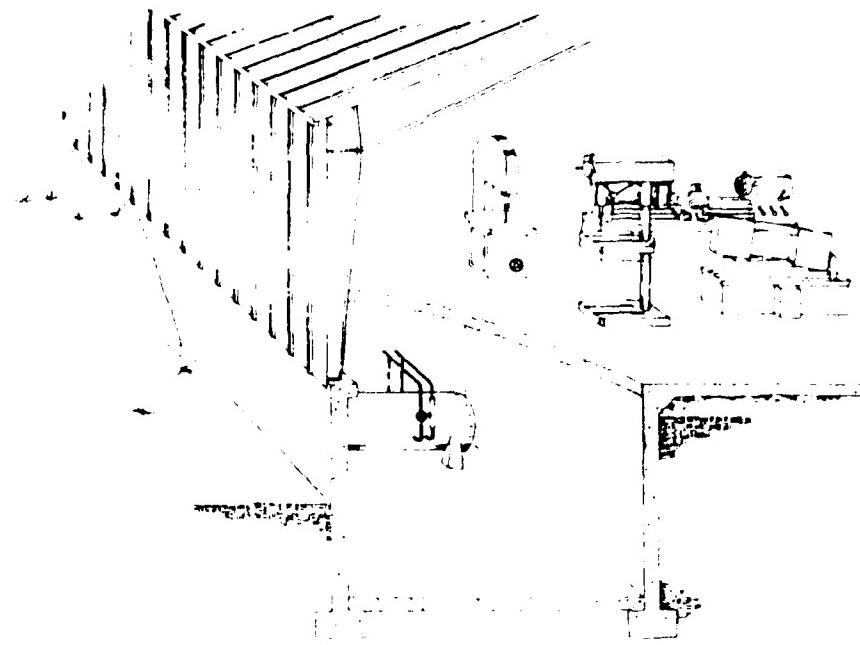
EVACUATE IT

TO SAVE YOUR EQUIPMENT

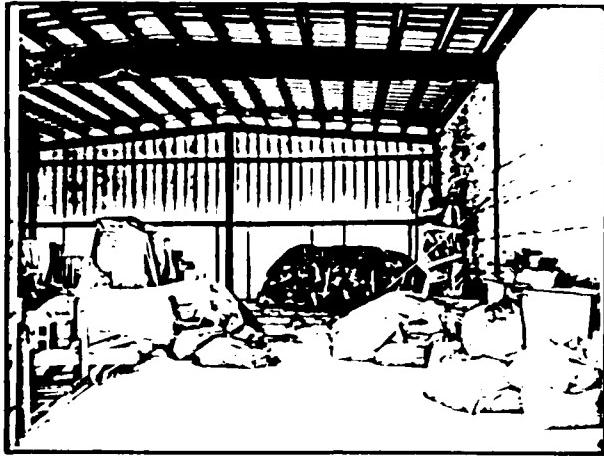


HARDEN IT IN PLACE

TO SAVE YOUR EQUIPMENT

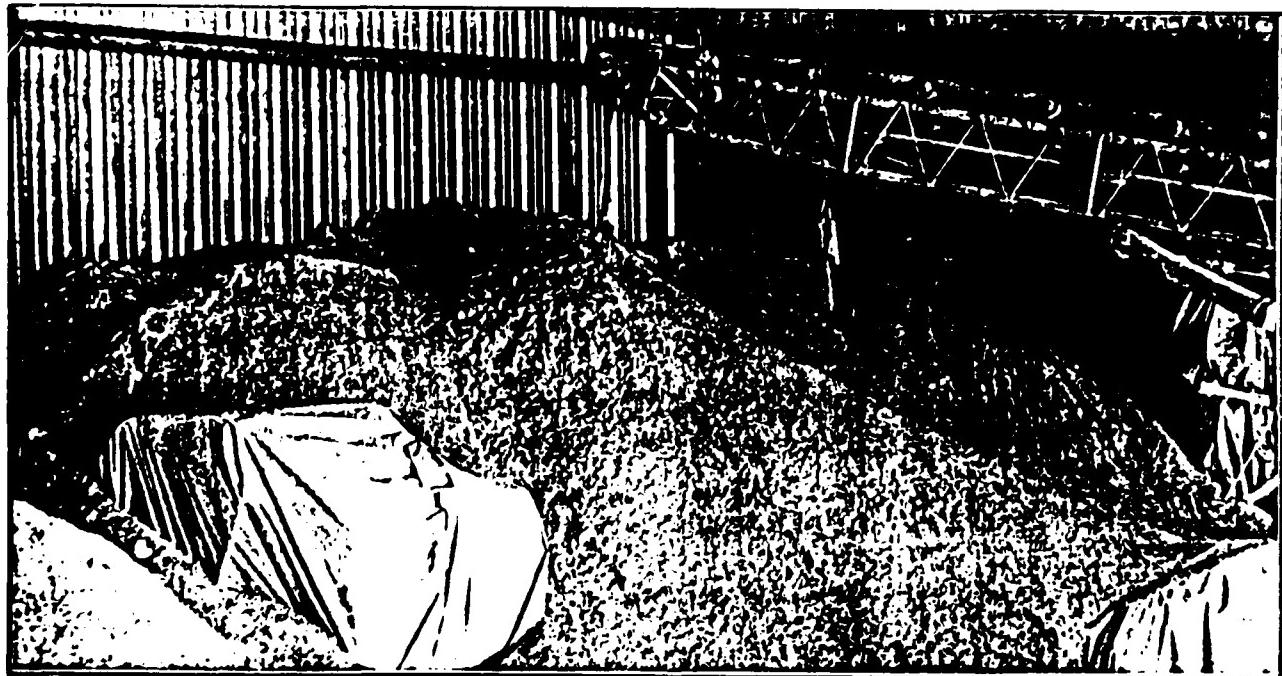


RELOCATE AND HARDEN IT



CRUSHABLE PACKING  
HELD IN PLACE BY  
PLASTIC SHEET FOR  
BURIAL PROTECTION

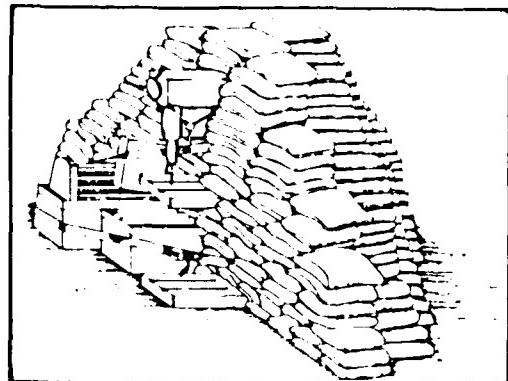
IF YOU CAN'T MOVE IT . . .



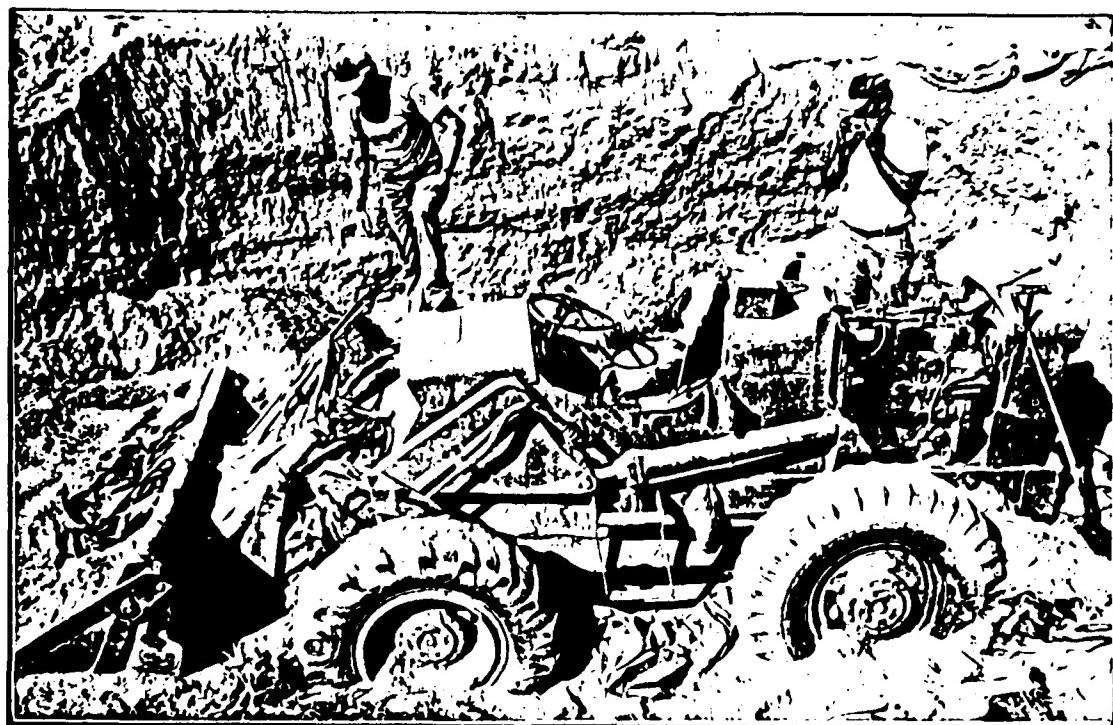
BURY IT IN-PLACE INDOORS .

IF YOU CAN MOVE THE EQUIPMENT BUT CAN'T HAUL IT AWAY

BURY IT OUTDOORS



IN PAVED AREAS - SANDBAG IT

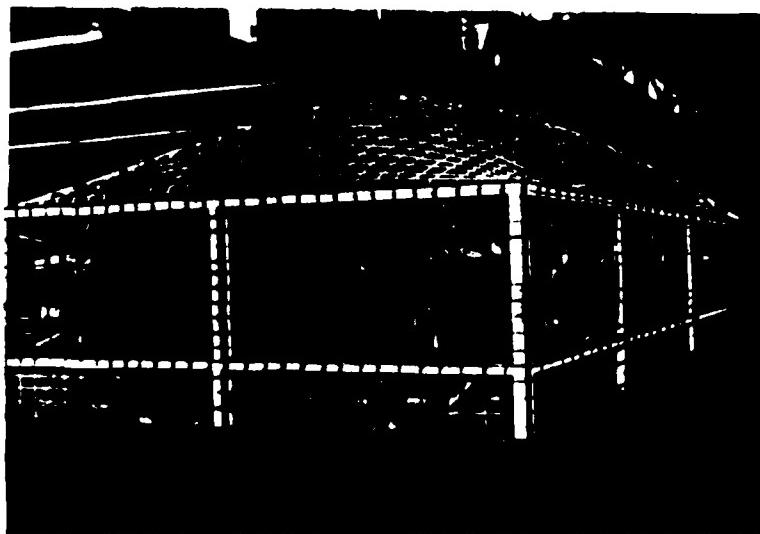


IN OPEN AREAS - PUT IT IN A TRENCH (COVER IT, IF THERE IS TIME)

IF YOU CAN'T BURY OR MOVE IT ...



CLUSTER MOBILE EQUIPMENT AROUND IT.  
WEDGE WOOD OR TIRE BUMPERS BETWEEN EQUIPMENT  
TO PROTECT KNOBS, HANDLES, ETC.



WELD HEAVY I-BEAM CRIB AROUND IT; ADD  
CHAIN LINK FENCE, STUFF WITH TIRES OR  
LUMBER, AND COVER.

BLAST PROTECTION: 20 TO 30 PSI

## **MANAGER'S PLANNING GUIDE**

When you have decided whom to assign to carry out the tasks, fill in the blank spaces with appropriate names and distribute the booklets accordingly. Booklets 5 and 6 should be filled out by the Coordinator and returned to the Hardening Operations Manager. Should an evacuation warning be given, your coordinators should be ready to take action.

**STEP 1** Distribute Booklet 1, **Management Planning Guide**, to  
Area Managers: \_\_\_\_\_

**STEP 2** Distribute Booklet 2, **Personnel Resources**, to: \_\_\_\_\_  
(coordinator)

**STEP 3** Distribute Booklet 3, **Host Area Shelters**, to: \_\_\_\_\_  
(coordinator)

**STEP 4** Distribute Booklet 4, **Protective Housekeeping**, to: \_\_\_\_\_  
(coordinator)

**STEP 5** Distribute Booklet 5, **Hardening Resources Inventory**, to: \_\_\_\_\_  
(coordinator)

**STEP 6** Distribute Booklet 6, **Equipment Inventory**, to: \_\_\_\_\_  
(coordinator)

When Booklets 5 and 6 have been completed and  
returned to the manager, complete Steps 7 and 8.

**STEP 7** Distribute Booklets 7, 8A & 8B, and 9 to: \_\_\_\_\_  
(hardening operations manager)

**STEP 8** Distribute Booklet 10, **Key Worker Shelter**, to: \_\_\_\_\_  
(coordinator)

# **INDUSTRIAL PROTECTION GUIDE**

**CRISIS RELOCATION  
INDUSTRIAL HARDENING PLAN**

**RESCUE & RELIEF  
IN INDUSTRY**

**INDUSTRY RELIEF**

## **CRISIS RELOCATION INDUSTRIAL HARDENING PLAN**

Booklet 2

### **PERSONNEL RESOURCES**

This is one of ten booklets of the Industrial Hardening Manual  
developed for the  
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**SCIENTIFIC SERVICE, Inc.**  
Redwood City, California 94063

Booklet 2

## PERSONNEL RESOURCES

**Coordinator:** \_\_\_\_\_  
(name)

**Alternate:** \_\_\_\_\_  
(name)

**Objective:** To develop plans for systematic relocation of employees and their dependents and to assess available skills.

This booklet is part of a plan to protect industrial plant equipment from possible damage in the event of a major disaster. It provides guidelines for developing an evacuation plan to move workers and their families to a safe area. Many impending disasters provide some kind of warning time, ranging from minutes to several days. With the longer warning times (e.g., hurricane, nuclear threat) it will be possible to evacuate populated areas.

Advance planning will allow you to:

- 1) Consult civil defense authorities, select your relocation site, and obtain pertinent printed matter.
- 2) Plan evacuation routes.
- 3) Coordinate transportation.
- 4) Define what everyone is to do and prepare alternatives in case of problems (defective vehicle, missing driver, etc.)
- 5) Provide a scheduled evacuation of personnel that will allow time to protect production equipment necessary to survival afterwards.

Your planning will make a difference. In a study conducted at a Boeing plant, 6,000 to 9,000 employees were able to complete a dry run exercise of the plant's industrial protection plan in three to four days.

## **INSTRUCTIONS FOR COORDINATOR**

Develop and maintain a list of all employees' names, according to addresses and cities (or districts, in a large city).

Consult your local Civil Defense office for information on evacuation, and obtain pamphlets, maps, etc., that will be used for your evacuation plan. Provide the CD authority with the total number of employees and dependents that will need shelter so he can arrange an evacuation site.

Recruit and assign an area leader by city, district, or districts, so there are ten to twenty employees per leader grouped in moderate sized neighborhoods.

Instruct area leaders with the information gathered from the Civil Defense office.

Provide a list of employees in each assigned district to the appropriate leader, and the name of leader to employees in his district.

Notify area leader when an employee moves into or out of his district.

Set up communication links with leaders.

Notify leaders to hold group meetings to confirm plans.

Notify leaders when to put evacuation plans into effect.

Assign Area Leader to develop records of the following information for each employee in his district:

- 1) Number of dependents needing transportation.
- 2) Capacity of transportation available at each employee's home.
- 3) Special skills of dependents; e.g., nursing, construction, entertainment.
- 4) Number of personnel who are classed as dependents of employees in other industries.
- 5) Number and kinds of medical problems requiring special diets, medicines, etc. (for example, diabetes), by person.

Late Planners' Note: If you start to plan after the evacuation warning is given, you will need a place large enough to assemble all company personnel. If the company has more than several hundred employees, then it may be necessary to divide into groups of one to two hundred, organized by city or district of residence. Then subdivide into groups of ten to twenty, by neighborhood, with an area leader to carry out subsequent tasks.

## **INSTRUCTIONS FOR AREA LEADER**

Use the records developed to organize and assign transportation -- assign drivers and use the largest capacity vehicles available.

Confirm assignments of riders and drivers so that all employees and families (plus supplies for two weeks of camping out) are assured of being evacuated. Establish a rendezvous point for all drivers in your group to ensure that everyone assigned in your district is accounted for before leaving for the safe area.

Prepare a backup plan in case of vehicle breakdown, and fix routes so missing members can be found quickly by tracing routes.

Notify members in your district of any assignment changes as they occur, or periodically.

Stress the importance of establishing and maintaining a schedule. Otherwise a late pick-up may take his own vehicle, create confusion, and add to traffic problems.

Distribute Civil Defense booklets including lists of what supplies to bring from home, how to shut down a household when an evacuation order is given by authorities, and what routes to take to get to the assigned safe area.

Conduct group meetings when the coordinator requires, to confirm assignments and understanding of members.

**Take charge of operations in your neighborhood on evacuation day.**

**Run an extra vehicle to provide for alternatives such as:**

- o Pick up nursery school children**
- o Pack extra food and gear**
- o Replace a vehicle if it breaks down and must be abandoned.**

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The following pages are excerpts from a Civil Defense manual, which should be available for distribution to your employees, either from your local Civil Defense authority or in-house.

#### WHAT SHOULD EVACUATE

The local areas around your company and your home could be potential targets if the United States is attacked. Areas where the greatest danger may exist are shown on the map. To protect the people living in these areas, plans have been made to relocate them to nearby areas which are considered to be safer from direct attack.

Those living in risk areas who do not leave according to instructions will be subject to strictly enforced curfews. Movement within the risk areas will be severely restricted to protect the property of those who have evacuated. In addition, most facilities or services cannot be provided in risk areas during the evacuation period. In general, food and retail outlets will be closed. Available food and goods will be used to supply the evacuated population in the reception areas.

If an attack occurs, the best existing public shelters within the risk areas will be reserved for key workers who will be working in essential industries, and for hospitalized or institutionalized people who cannot be evacuated. Water, electricity, and gas service may be shut off. You may become isolated in a risk area.

#### WHAT WILL DO

When official notification is given, all those living in the risk area shown on the map will be directed to evacuate to reception areas in nearby counties; that is, from a place of possible danger to a place of greater safety.

You can determine whether you should evacuate by looking where you live on the map. If it is within a risk area, you should be prepared to leave if notification is given. Two days, or possibly more, will be available to complete the evacuation. However, you should prepare now.

#### WHAT TO DO BEFORE YOU LEAVE

If you have chosen to relocate with your company, determine what route you are to take and listen to your transistor radio to hear if traffic is moving on it, or if an alternate route is designated. Re-unite with all family members who would normally travel with you, including nursing home residents, etc. Unless you are directed otherwise (see following box) this may delay your departure.

Make certain your vehicle contains as many of the items on page 3 as possible, or the items specified, if you are to be picked up. Make sure your vehicle is filled with fuel and normal emergency road equipment. Emergency gas stations are listed on page . Turn all utilities in your home off at the main — water, gas, electricity. Stay tuned to a station providing updated information in your area. Depart as close to the time suggested as you can.

#### IF YOU HAVE A FAMILY MEMBER IN A HOSPITAL, NURSING HOME, ETC.

Collect ambulatory patients not requiring close medical attention. Most hospital patients will be evacuated. However, if it is impossible for one to be moved because of special care requirements, that person will be cared for during the evacuation period. Similar consideration will be given to those residing in other institutions. Shelter and care will be provided in case of an imminent attack.

#### WHAT TO DO WHEN YOU ARRIVE

When you reach a major community or town in your assigned reception county, proceed immediately to your assigned reception area.

At the center, you will register yourself and your family. Reception county officials will make every effort to assign you to a place to sleep, in a larger building or possibly with a private household that has volunteered to share their home.

#### Lodging in Public Buildings...

If you are assigned to a public building such as a school, church, or other temporary lodging center, do everything you can to help maintain order and sanitary living conditions. Elect a leader and form working groups to help local officials and volunteers with such tasks as:

- o Cooking and feeding services
- o Providing water supply
- o Cleaning up trash and garbage
- o Maintaining order
- o Assuring quiet during sleeping hours
- o Organizing recreation and religious activities
- o Arranging medical care for the sick and assisting the handicapped.

#### HOW TO KEEP INFORMED

Listen to the radio for information and advice from National, State, and local officials. You will be told when you should return home. DO NOT RETURN HOME BEFORE YOU ARE ADVISED TO DO SO. It is impossible to predict how long you will have to stay in the reception area. It could be only for a few days or could last for a week or more.

If a nuclear attack should occur and the Emergency Broadcasting System (EBS) is in operation, a number of radio broadcast stations will remain on the air to provide emergency information. All other radio stations will stop broadcasting. Those emergency stations remaining on the air will provide you with information and instructions that you will need.

#### WHAT TO TAKE

You should prepare to take those things you would take for a vacation trip of a week or more - plus other items on the checklist on page 3. Do not take all your favorite belongings. Your home and property will be protected from looters while you are away.

The checklist on page 3 includes items you will need for your stay in the reception area. It also includes tools needed to construct a fallout shelter and those things you will need to take into the shelter if an attack occurs.

All items on this list should be included if you are going to use your own car for transportation. If you do not have a car and will be using company transportation, take only those items which have been marked on the list given on page 3.

#### PETS

No arrangements have been made to house pets in the reception area. Therefore, if you take your pet with you, it will probably be confined to your car and you will be responsible for its care. If you elect to leave your pets behind, be sure they are confined in a sheltered area with an adequate supply of food and water. Above all, do not turn your pet loose to fend for itself while you are gone.

#### HOW TO GET THERE

If you have a car, truck, camper, or recreation vehicle, drive to your designated reception area, using the route planned. Remember that several days should be available for relocating all those living in the risk area. Take the time you need to prepare and pack.

Evacuation routes have been designated to assure residents will be equally distributed among the reception counties so that there will be adequate food and lodging for you and your family. If you use a route not assigned to you, you may find the reception area you have chosen is filled, and there is no room or accommodations for you. Follow the evacuation route to the reception county as indicated. Wherever possible, police officers will be on duty to advise and direct you. Obey all instructions by law enforcement officers.

If you get caught in a traffic jam, turn off your engine, remain in your car, listen for official instructions (but not on your car radio), and be patient. Do not get out of line to find an alternate route. All routes will be crowded. If traffic is stopped for an hour or more, do not leave your car for any reason.

Be sure you have adequate gasoline when you start out. DO NOT BUY ANY MORE GAS THAN YOU WILL NEED. Gasoline will be in short supply and will be needed to provide you with food and other essential supplies. But if you run out of gas or have other mechanical difficulties, move your car to the side of the road out of the traffic lanes to allow traffic to continue. Service to stalled autos will be available during the evacuation period. Leave your hood up as a sign that you are stalled, and you will be assisted as soon as possible.

## FREAPARE !

Here are some things you can do that will better prepare you and your family to survive and recover if a nuclear attack should occur.

- o Go over the checklist of things to take with you. If you will need prescription medicines or special food, check to see if you have an ample supply.
- o Collect all of your valuable papers and put them in one place, preferably wrapped in plastic in a metal container (tool box, fishing tackle box).
- o Check your home for security. See that all locks are secure. Store valuables in a safe place. Shut off utilities if you evacuate or if attack is likely.

o Close all window blinds, shades, and draperies. This can help prevent fires from the heat wave of a nuclear explosion.

o If you will use your car, be sure you have enough gasoline.

o Be sure to take tools — especially SHOVELS, PICKS, HAMMERS. These will be essential in improvising fallout shelters. Also take work gloves.

o Stay tuned to your local TV or radio station for instructions. They will broadcast the notice to evacuate, if directed by government officials.

Read this supplement carefully and discuss it with your family. If you have special problems not discussed in these instructions —

CALL \_\_\_\_\_

### SURVIVAL SUPPLIES . . . FROM YOUR HOME . . . FOR YOUR FAMILY

CLOTHING AND BEDDING	PERSONAL, SAFETY, SANITATION, AND MEDICAL SUPPLIES	TOOLS FOR CONSTRUCTING A FALLOUT SHELTER
<input type="checkbox"/> work gloves <input type="checkbox"/> work clothes <input type="checkbox"/> extra underclothing <input type="checkbox"/> outer wear (depending on season) <input type="checkbox"/> rain garment <input type="checkbox"/> extra pair of shoes <input type="checkbox"/> extra socks or stockings <input type="checkbox"/> blankets and sheets <input type="checkbox"/> 1 sleeping bag per person, plus <input type="checkbox"/> 1 suitcase per person	<input type="checkbox"/> battery operated (transistor) radios, extra batteries <input type="checkbox"/> flashlight, extra batteries <input type="checkbox"/> soap <input type="checkbox"/> toothbrush & toothpaste <input type="checkbox"/> shaving articles <input type="checkbox"/> sanitary napkins <input type="checkbox"/> detergent <input type="checkbox"/> towels and washcloths <input type="checkbox"/> toilet paper <input type="checkbox"/> emergency toilet <input type="checkbox"/> garbage can <input type="checkbox"/> newspapers <input type="checkbox"/> first aid kit <input type="checkbox"/> special medication (insulin, heart tablets, or other)	<input type="checkbox"/> pickax <input type="checkbox"/> shovel <input type="checkbox"/> saw <input type="checkbox"/> hammer <input type="checkbox"/> broom <input type="checkbox"/> ax <input type="checkbox"/> crowbar <input type="checkbox"/> nails and screws <input type="checkbox"/> screw driver <input type="checkbox"/> wrench
FOOD AND UTENSILS	BABY SUPPLIES	IMPORTANT PAPERS
<input type="checkbox"/> take all the food you can carry (particularly dried or canned food requiring little preparation) <input type="checkbox"/> water <input type="checkbox"/> thermos jug or plastic bottles <input type="checkbox"/> bottle and can opener <input type="checkbox"/> eating utensils <input type="checkbox"/> plastic or paper plates, cups, and napkins <input type="checkbox"/> candles and matches <input type="checkbox"/> plastic drop cloth	<input type="checkbox"/> diapers <input type="checkbox"/> bottles and nipples <input type="checkbox"/> milk or formula <input type="checkbox"/> powder <input type="checkbox"/> rubber sheeting, etc. <input type="checkbox"/> 1 suitcase	<input type="checkbox"/> Social Security card <input type="checkbox"/> deeds <input type="checkbox"/> insurance policies <input type="checkbox"/> stocks and bonds <input type="checkbox"/> will <input type="checkbox"/> savings account books <input type="checkbox"/> credit cards, checks, and currency <input type="checkbox"/> lockbox
DO NOT TAKE		<input type="checkbox"/> FIREARMS —(Guns of any kind) <input type="checkbox"/> NARCOTICS <input type="checkbox"/> ALCOHOLIC BEVERAGES

*Excerpted from "Preparing Crisis Relocation Planning Emergency Public Information," Working Draft CPG-2-8-F, February 1977.*

**SAMPLE MEAL PLANS: *No Cooking Facilities***

First day	Second day	Third day
MORNING		
Citrus fruit juice. <sup>1</sup> Ready-to-eat cereal. Milk, cold coffee, <sup>2</sup> or tea. <sup>2</sup> Crackers. Peanut butter or other spread	Fruit juice. <sup>1</sup> Corned beef hash. <sup>1</sup> Crackers. Spread. Milk, cold coffee, <sup>2</sup> or tea. <sup>2</sup>	Citrus fruit segments. <sup>1</sup> Ready-to-eat cereal. Instant cereal. <sup>1</sup> Milk, cold coffee, <sup>2</sup> or tea. <sup>2</sup>
Spaghetti with meat sauce. <sup>1</sup> Green beans. <sup>1</sup> Crackers. Spread. Milk, cold coffee, <sup>2</sup> or tea. <sup>2</sup>	Baked beans. <sup>1</sup> Brown bread. <sup>1</sup> Tomatoes. <sup>1</sup> Fruit. <sup>1</sup> Milk, cold coffee, <sup>2</sup> or tea. <sup>2</sup>	Chile con carne with beans. <sup>1</sup> Crackers. Fruit. <sup>1</sup> Cookies. Milk, cold coffee, <sup>2</sup> or tea. <sup>2</sup>
BETWEEN MEALS		
Fruit-flavored drink or fruit drink	Milk.	Tomato juice.
NIGHT		
Lunch meat. <sup>1</sup> Sweetpotatoes. <sup>1</sup> Applesauce. <sup>1</sup> Milk, cold coffee, <sup>2</sup> or tea. <sup>2</sup> Candy.	Pork and gravy. <sup>1</sup> Cereals. <sup>1</sup> Potatoes. <sup>1</sup> Instant pudding. Fruit juice. <sup>1</sup>	Steak. <sup>1</sup> Cheese and cheese. <sup>1</sup> Pasta and carrots. <sup>1</sup> Crackers. Milk, cold coffee, <sup>2</sup> or tea. <sup>2</sup>

<sup>1</sup> Canned.    <sup>2</sup> Instant.

**SAMPLE MEAL PLANS: *Limited Cooking Facilities***

First day	Second day	Third day
MORNING		
Citrus fruit juice. <sup>1</sup> Ready-to-eat cereal. Milk. Hot coffee, <sup>2</sup> tea, <sup>2</sup> or cocoa. <sup>2</sup>	Citrus fruit juice. <sup>1</sup> Hot cereal (quick-cooking). Milk. Hot coffee, <sup>2</sup> tea, <sup>2</sup> or cocoa. <sup>2</sup>	Prunes. <sup>1</sup> Ready-to-eat cereal. Milk. Crackers. Cheese. Hot coffee, <sup>2</sup> tea, <sup>2</sup> or cocoa. <sup>2</sup>
Vegetable soup. <sup>1</sup> Potato salad. <sup>1</sup> Crackers. Harm spread. <sup>1</sup> Milk. Candy bar.	Beef-and-vegetable stew. <sup>1</sup> Green beans. <sup>1</sup> Crackers. Peanut butter. Milk.	Chile con carne with beans. <sup>1</sup> Tomatoes. <sup>1</sup> Crackers. Hot coffee, <sup>2</sup> tea, <sup>2</sup> or cocoa. <sup>2</sup>
BETWEEN MEALS		
Fruit-flavored drink or fruit drink.	Tomato juice. <sup>1</sup>	Fruit-flavored drink or fruit drink.
NIGHT		
Beef and gravy. <sup>1</sup> Noodles. <sup>1</sup> Peas and carrots. <sup>1</sup> Instant pudding. <sup>1</sup> Hot coffee, <sup>2</sup> tea, <sup>2</sup> or cocoa. <sup>2</sup>	Tuna fish, <sup>1</sup> cream of celery soup, <sup>1</sup> mixed sweet pickles <sup>1</sup> —combined in one dish. Fruit. <sup>1</sup> Cookies. Hot coffee, <sup>2</sup> tea, <sup>2</sup> or cocoa. <sup>2</sup>	Lunch meat. <sup>1</sup> Hominy. <sup>1</sup> Applesauce. <sup>1</sup> Cookies. Peanuts. Hot coffee, <sup>2</sup> tea, <sup>2</sup> or cocoa. <sup>2</sup>

<sup>1</sup> Canned.    <sup>2</sup> Instant.

*Excerpted from "Preparing Crisis Meal Planning Emergency Public Information," Working Draft -2-8-F, February 1977.*

**INDUSTRIAL**

**PROTECTION**

**GUIDE**

**CRISIS RELOCATION  
INDUSTRIAL HARDENING PLAN**

**HOST  
AREA  
SHELTERS  
BOOKLET 3**

**SCIENTIFIC SERVICE, INC.**

**CRISIS RELOCATION INDUSTRIAL HARDENING PLAN**

Booklet 3

**HOST AREA SHELTERS**

This is one of ten booklets of the Industrial Hardening Manual  
developed for the  
Federal Emergency Management Agency  
under Contract No. EMW-C-0154, Work Unit 1124E

**SCIENTIFIC SERVICE, Inc.**  
Redwood City, California 94063

Booklet 3  
**HOST AREA SHELTERS**

**Coordinator:** \_\_\_\_\_

(name)

**Alternate:** \_\_\_\_\_

(name)

**Objective:** To provide direction for establishing shelter space in the host area for employees and their families to relocate to in an emergency.

This booklet is part of a plan to protect industrial plant equipment from possible damage in the event of a major disaster. It provides design and construction information necessary to establish shelters in the host area (see Glossary, page 45) for use during the crisis period. Included are both quick-fix converted shelters, and expedient shelters where there is nothing to convert.

By organizing this primary survival task, there is a greater chance that other tasks to enhance plant survival will be carried out also -- and survival as an organized group of families is easier and more likely than families alone.

## **TASK SUMMARY**

1. Determine number of employees and family members evacuating.
2. Define shelter and space requirements needed to accommodate sheltrees.
3. Establish shelter stocking requirements.
4. Establish host area liaison, obtain and survey assigned space, assess upgrading requirements.
5. Estimate materials, equipment, labor, and time required to prepare shelter space.
6. Complete logistics preparation and upgrading sequence so you will be prepared to implement beginning on warning day.

### **Task 1: Determine the Number of Shelters**

Obtain the following information from the coordinator of Booklet 2:

1. Number of persons to be sheltered (employees plus dependents)
  - (A) Age
  - (B) Special skills
2. Numbers of persons with special physical, medical, or dietary needs.

Use this information to figure shelter space and stocking requirements and to submit to your local Civil Defense Office with your request for a Host Area assignment. Refer to the Task 1 checklist, page 5.

### **Task 2: Shelter Space Requirements**

Using Task 1 information, plan enough shelter space and supplies for everybody to survive two weeks without need to leave the shelter. You will need at least 10 square feet of floor space and 65 cubic feet of air volume per person, plus storage space for supplies. (Refer to the Task 2 checklist, page 5.)

#### **What else to look for:**

- o Shelters must support the equivalent of two feet of earth cover.
- o Shelters should be located so that collapsing buildings, trees, junk, or debris will not prevent escape of sheltered personnel.
- o Two exits should be provided, located as far apart as practicable. Because debris may block one exit, an alternative escape exit should be available.
- o Below ground shelters, unless water-tight, should not be located in areas with high ground water or subject to flooding from surface runoff, ruptured tanks, or broken pipelines.

- o Shelters should **not** be located near hazardous or flammable materials.
- o Existing basement areas that are potentially available for upgrading and existing underground facilities must be capable of being cleaned and made habitable in 72 hours. The extent of cleaning necessary will depend on shelter option selected.

**Equipment Needed:**

A fully equipped shelter should contain the following:

- o A complete life support system adequate for a minimum of two weeks stay-time. A detailed list is included in the Task 3 section.
- o Ventilation equipment adequate to supply at least 3 cubic feet per minute per person. (Larger air volumes to 40 cfm, or an air-drying system, may be required in the hot or humid areas of the country.) Hand-cranked systems are desirable, as power may be unavailable.
- o Emergency power system.
- o Radiation monitoring equipment.
- o Communication equipment, battery-powered with rechargeable cells.
- o Battery charger or spare batteries.
- o Sleeping facilities.
- o Firefighting equipment.
- o Tools and equipment stored inside to aid in exiting the shelter, to remove debris and roadblocks during evacuation, and for rescue of people from other shelters as necessary.

## HOST AREA SHELTERS - SPACE REQUIREMENTS

### TASK I & II CHECKLIST

Number of Shelterees ( \_\_\_\_\_ )  
Company Name

- 1) Number of Men \_\_\_\_\_
- 2) Number of Women \_\_\_\_\_
- 3) Number of Children \_\_\_\_\_
- 4) Number of Handicapped \_\_\_\_\_

Sheltered Total Number \_\_\_\_\_

### TASK II

#### Shelter Space Requirements

- 1) Floor Space  $10 \times$  Sheltered Total Number = \_\_\_\_\_ S.F.
- 2) Allowance for Shelter Stocking and Equipment Storage (from Task III Checklist) = \_\_\_\_\_ S.F.  
Total \_\_\_\_\_ S.F.
- 3) Air Volume  $65 \times$  Sheltered Total Number = \_\_\_\_\_ C.F.
- 4) Ventilation = 3 cubic feet per minute per person.  
 $3 \times$  Sheltered Total Number \_\_\_\_\_ CFM\*

\* Provide for additional capacity in humid areas, up to 40 CFM per person.

Provide copies of this form as follows:

- 1 to local Civil Defense Office with request for Host Area space.
- 1 to Host Area Civil Defense official when contacted.
- 1 to owner of shelter space.

### **Task 3: Establish Shelter Stocking Requirements**

**Shelter Stocking:** Early planning for provision of food, medical and other supplies must be made, since warning of an impending disaster may not leave sufficient time for last minute preparation (not to mention purchases). Each Host Area shelter should be provided with a minimum of two weeks supply of food and water for each shelteree. Note that although shelterees are instructed to bring supplies when they evacuate, not all of them will. Those supplies brought will provide additional backup for Host Area emergencies.

**Water Supply:** An adequate water supply is very important to survival. A healthy individual can survive for four weeks without food, but will not survive more than a few days without water or similar fluids. The minimum water each individual should be provided for survival is one gallon per day -- one-half gallon for drinking and one-half gallon for other purposes. The water must be accessible from inside the shelter. It can be stored in containers in the shelter or connected to an external storage source independent of municipal supply systems. A supply of 17 gallons per person is a good estimate, and includes a 20% contingency.

**Food Supply:** To provide a food stockpile, three factors are important: (1) nourishment (food value in relation to volume); (2) long shelf life; and (3) ease of preparation. Of less importance are palatability and cost. Balanced diets are not necessary, since the food is intended for only a limited survival period.

Select foods that require little storage space, that keep for months without refrigeration, and that can be eaten uncooked, if necessary. Canned foods will stay in good condition for six or more months if kept in a dry, cool, dark place (preferably not above 70° F, or below freezing). Replace canned foods at least once a year and uncanned packaged foods at least every three months. Food purchased for shelter use should be provided in container sizes that minimize waste. This should be simple to manage at meal time.

Diabetics, or persons with food tolerance or food allergy problems, may require special diets and/or medication. Special requirements should be

established, and provisions made: Stocking, refrigeration, and assignment where these supplies and attention can be provided. A sick shelteree will become a management and morale problem.

Table 1 is a list of foods suitable for shelter use to supply one adult a minimum of 2,000 calories per day.

**Special Shelter Stay Considerations:** Some special shelter stocking items and considerations are important to the safety and welfare of shelterees. These items are listed in Table 2.

**Radio:** An operating battery-powered radio is essential to shelter life, morale, and recovery. Since radio reception is cut down by radiation protection, a radio reception check must be made as soon as the shelter is completed. An outside antenna will be necessary to receive CONELRAD broadcasts, which have weaker signals than normal broadcasts.

**Fire Extinguisher:** An operating fire extinguisher should be accessible in each shelter. The close quarter environment would result in disaster if even a small fire started. It should be selected to be safe to use in an enclosed space.

**Waste Disposal:** Long-term storing of garbage and human wastes inside the shelter may create a health hazard. Within three or four days it should be safe to make short forays outside, so wastes should be buried at a previously selected location near the shelter -- a minimum of 12 inches in the earth is required. If the disposal area is excavated prior to the time shelterees enter the shelter, exposure time for people performing waste disposal will be minimized. Canvas boots or plastic bags should be worn on shoes when leaving the shelter and removed when entering. Disinfectants and deodorizers should be stored in the shelter to treat wastes until disposal.

**Checklist:** A stocking requirements checklist is provided on page 11. You will need to complete it so that checklists I and II may be completed.

TABLE 1. REQUIRED FOOD SUPPLIES PER PERSON FOR HOST AREA SHELTERS  
(Long Stay-Time up to 2 weeks)

Food Item	Total Weight*	Daily Amount
<u>Water</u> - Stored in a dark place in clean containers with tight fitting lids. Rinse and refill containers every 3 months. 14 gals		4 qts
<u>Milk</u> - Nonfat, dry	20 oz	1/3 cup
Evaporated	14 oz	1 oz
<u>Juices</u> - Tomato, grape, apple. In crown capped bottles only. Store upright.	64 oz	1/2 cup
<u>Fruits</u> - Applesauce, pears, peaches. In glass jars, glass lids only. Store upright.	112 oz	1 cup
<u>Vegetables</u> - Corn, peas, beans, spinach	112 oz	1 cup
<u>Soups</u> - Canned or dehydrated (in can).	112 oz	1 cup
<u>One-Dish Meals</u> - Canned goods including chicken and rice or noodles, pork and beans, baked kidney beans, chile con carne, and beef stew.	208 oz	2 cups
<u>Spreads</u> - Jam, jelly, marmalade	14 oz	1 tbs
Peanut butter	14 oz	1 tbs
<u>Crackers</u> - in glass or cans.	56 oz	25 - 30
<u>Beverages</u> - Instant coffee, tea or cocoa	4 oz	3 tsp
<u>Sugar</u>	4 oz	3 tsp
<u>Hard Candies</u>	16 oz	1 oz
<u>Salt</u>	4 oz	1/4 oz
<u>Sterno</u>	4 cans	1/4 can

\* To provide a sufficient amount, add 20% to the above quantities

TABLE 2. HOST AREA ESSENTIAL SUPPLIES  
(Long Stay-Time up to 2 weeks)

Cooking & Serving Equipment

- Cooking unit
- Cups
- Napkins or paper towels
- Bottle opener
- Plates
- Matches
- Can opener (2)
- Double boiler
- Eating utensils
- Measuring cup
- Pocket knife
- Large boiling (5 or 10 gal) kettle

Clothing & Bedding

- Towels and wash cloths
- Sleeping bags or blankets & sheets
- Spare clothing

Sanitation Supplies

- Soap
- Toilet tissue & sanitary napkins
- Disinfectant (chlorine, bleach)
- Insecticide
- Garbage can
- Human waste can
- Emergency toilet
- Plastic bags with ties (18 per person)
- First aid kit (large)

Tools & Miscellaneous Items

- Candles
- Hammer
- Wrench
- Bucket
- Shovel
- Pliers
- Screwdriver
- Brooms (small)
- Batteries
- Flashlight
- Calendar
- Clock or watch
- Axe
- Crowbar

Emergency Generator, fuel and oil with necessary cords, plugs, lights

TABLE 2. HOST AREA ESSENTIAL SUPPLIES (contd)  
(Long Stay-Time up to 2 Weeks)

Radio (battery operated with spares)

Battery Charger for radio batteries

Radiological monitoring equipment

Evacuation Supplies

Gasoline

Tent

50-mile map of area

Recreational & Spiritual Supplies

Bible

Books

Games

Song books

HOST AREA SHELTERS - STOCKING REQUIREMENTS

TASK III CHECKLIST

Shelter Stocking Requirements (2 Week Stay-Time)

- 1) Total the space required in the shelter(s) for water, food, and supplies, including additional space for supplies brought by evacuees (shelterees). These supplies should be accessible without leaving the shelter.

Equivalent Floor Space \_\_\_\_\_ S.F.

- 2) Identify special foods, supplies, or special dietary needs for shelterees that require them. Provide a 3-week supply for such persons and make necessary designations on supplies to indicate their shelter destination and proposed use.

Equivalent Floor Space \_\_\_\_\_ S.F.

- 3) Provide a radio for each shelter, and test it inside shelter for performance under shelter conditions — provide extra batteries.

Equivalent Floor Space \_\_\_\_\_ S.F.

- 4) Provide sealed cans for food and human waste.

Equivalent Floor Space \_\_\_\_\_ S.F.

- 5) Provide radiation detector in each shelter.

Equivalent Floor Space \_\_\_\_\_ S.F.

- 6) Provide fire extinguishers.

Equivalent Floor Space \_\_\_\_\_ S.F.

Total Floor Space Allowance: \* \_\_\_\_\_ S.F.

\* Total to be entered on Line 2, Task II Checklist, page 5.

#### **Task 4: Host Area Liaison, Assignment and Assessment of Shelter Space**

- o Provide a copy of the completed Task I and Task II checklists to your local Civil Defense office so that the information can be used to coordinate allocation of Host Area shelter spaces. Your local Civil Defense office will provide you with the name of the Host Area Civil Defense contact for your company. If no information is available, try the State Office of Emergency Services -- or go to the alternatives in Appendix A, if time is short.
- o When you obtain the name of the Host Area contact, send a representative to confirm the number of evacuees needing shelter (Task 1 checklist). Have him identify the assigned shelter space, and make a preliminary site reconnaissance of the space using Task 4 checklists 1 and 2. The remainder of this Task 4 section indicates how to do this.
- o Your representative should meet with the shelter space owner as well as the Host Area Civil Defense people to review your shelter assessment form. Lack of Host Area response in converting the assigned building space into an effective shelter, or any other incompatibilities in timing, upgrading, resources, or interfaces identified on the form may require the use of alternative space delineated in Appendix A. The possibility of interface problems should be discussed before your representative meets with the Host Area people. The goal of his assignment is to determine the specific course of action that is best so that resources can be allocated and unnecessary problems avoided.
- o At the Host Area meeting, your representative should arrange for and provide secure storage space for all upgrading resources and stocking supplies. Storage should be as near the shelter area as possible.

HOST AREA SHELTERS - SHELTER IDENTIFICATION

TASK IV CHECKLIST 1

Owner and Site Identification  
(Use one sheet for each assigned building)

Assigned Facility I.D. Date \_\_\_\_\_  
Owner's Name \_\_\_\_\_ Owner's phone No. \_\_\_\_\_  
Owner's Address \_\_\_\_\_  
Building Name \_\_\_\_\_  
Street Address \_\_\_\_\_  
City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_ X-Street \_\_\_\_\_  
No. Stories \_\_\_\_\_ No. of Basement Levels \_\_\_\_\_  
Use \_\_\_\_\_ Special Facilities \_\_\_\_\_

General Facility Data

Yr. Built \_\_\_\_\_ Building Pop. \_\_\_\_\_ Air Source Natural \_\_\_\_\_ Mech. \_\_\_\_\_  
Water Storage \_\_\_\_\_ gals. Water Source \_\_\_\_\_ Heating \_\_\_\_\_ Aux. Power \_\_\_\_\_  
General Public Access Commodes \_\_\_\_\_

Shelter Space Reconnaissance and Review

- |  | <u>Yes</u>  | <u>No</u> |
|--|---|-----------|
| a) Will owner make space accessible?             | ____  | ____      |
| b) Is space to be used now empty?                | ____  | ____      |
| c) Is stored material relocatable now?           | ____  | ____      |
| d) Will owner relocate it (or will you have to)? | ____  | ____      |
| e) Floor Type                                    | Ceiling Type (pull out dropped ceiling<br>section to determine) |           |
| Wood _____                                       | ____  | ____      |
| Concrete _____                                   | ____  | ____      |
| Steel _____                                      | ____  | ____      |

HOST AREA SHELTERS - UPGRADING

TASK IV CHECKLIST 2

Basement Shelter Option

- 1) Available basement area? \_\_\_\_\_ Is it upgradable? \_\_\_\_\_

If not, locate expedient shelter option. (see Expedient shelter checklist,  
Appendix A)

- 2) Space upgrading Length \_\_\_\_\_ Width \_\_\_\_\_ Height \_\_\_\_\_

a) Type of upgrading Studwall \_\_\_\_\_

Post & Beam \_\_\_\_\_

- b) Number of exits, windows and other passages for closures required?  
(All openings must be closed off so that radiation levels in the  
shelter can be controlled.) \_\_\_\_\_

Closure Requirement

Dimensions: \_\_\_\_\_ x \_\_\_\_\_

\_\_\_\_\_ x \_\_\_\_\_

\_\_\_\_\_ x \_\_\_\_\_

\_\_\_\_\_ x \_\_\_\_\_

- c) Ventilation equipment?

Is shelter space adequately ventilated? \_\_\_\_\_

Can shelter space be adequately ventilated? \_\_\_\_\_

Are ventilation resources available? \_\_\_\_\_

- 3) Upgrading resources

a) Are lumber and other materials available for upgrading? Yes \_\_\_\_\_ No \_\_\_\_\_

Locally? \_\_\_\_\_

b) Are tools and equipment available for upgrading? Yes \_\_\_\_\_ No \_\_\_\_\_

Locally? \_\_\_\_\_

TASK IV CHECKLIST 2 (contd)

- 4) Earth radiation protection of ceiling.      Yes      No
- a) Can ceiling area be earth protected?  
(structural capability)      \_\_\_\_\_
- b) Is ceiling area accessible for adding  
2 ft of soil for radiation protection?      \_\_\_\_\_
- c) Will owner allow placement of soil for  
radiation protection on ceiling?      \_\_\_\_\_
- d) Are tools and equipment available to  
place earth?      \_\_\_\_\_
- 5) Is earth material available for radiation  
protection?      \_\_\_\_\_
- a) If available for protection at what distance? \_\_\_\_\_ miles
- 6) Secure storage  
a) Is secure storage for resources, materials  
or tools available?      Yes \_\_\_\_\_ No \_\_\_\_\_

The following information is to help your representative assess the shelter space & complete the checklists.

### **Upgrading Requirements**

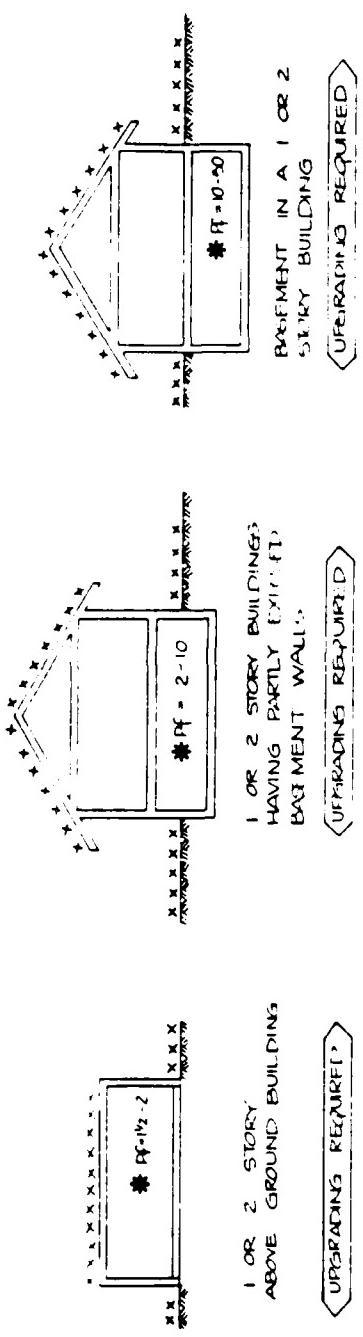
Two considerations are basic to shelter development in Host Areas:

- (1) Adequate radiation protection
- (2) Sufficient structural integrity to support the radiation protection and 2 psi blast overpressures.

The greatest protection from radiation effects can be achieved in below ground, or partially below ground, basement structures. This is shown in Figure 1, and is the basis of the "upgrading" concept for shelter use.

### **Existing Building Structures**

Because below ground structures provide greater radiation protection capability, this manual emphasizes these structures. The majority of below ground structures in Host Areas will be concrete wall basement areas with timber joist and beam ceiling construction. Typical details of this type of construction are shown in Figure 2.



1 OR 2 STORY  
ABOVE GROUND BUILDINGS

PF = 1/2 - 2  
PF = 2-10  
PF = RADIATION PROTECTION FACTOR IS THE AMOUNT OF PROTECTION  
INSIDE A SHELTER COMPARED TO OUTSIDE.

**UPGRADING REQUIRED**

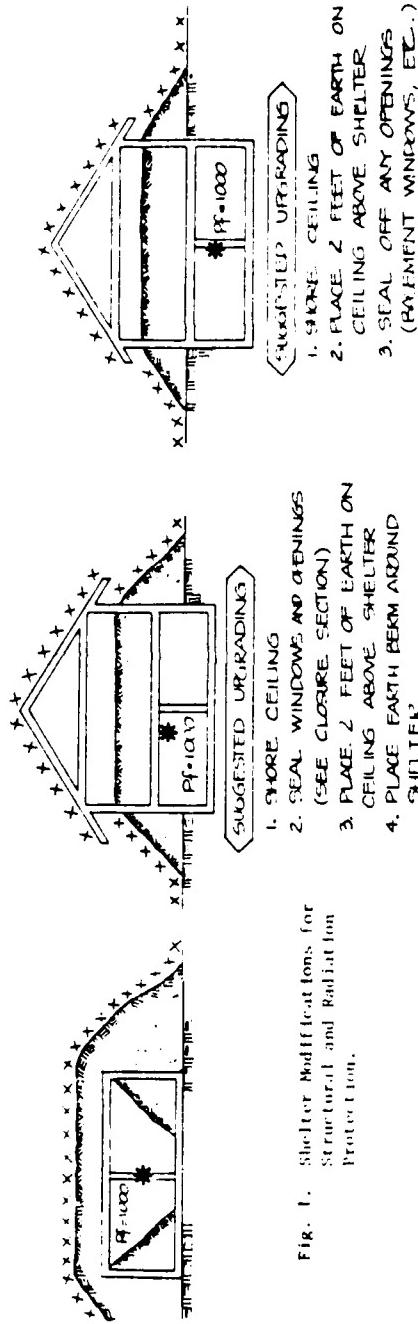
OPTIMUM LOCATION IN STRUCTURE.

XXX = FALLOUT LOCATION ON AND AROUND STRUCTURE.

PF = RADIATION PROTECTION FACTOR IS THE AMOUNT OF PROTECTION  
INSIDE A SHELTER COMPARED TO OUTSIDE.

**SUGGESTED UPGRADE**

17



FIR. 1. Shelter Modifications for Structural and Radiation Protection.

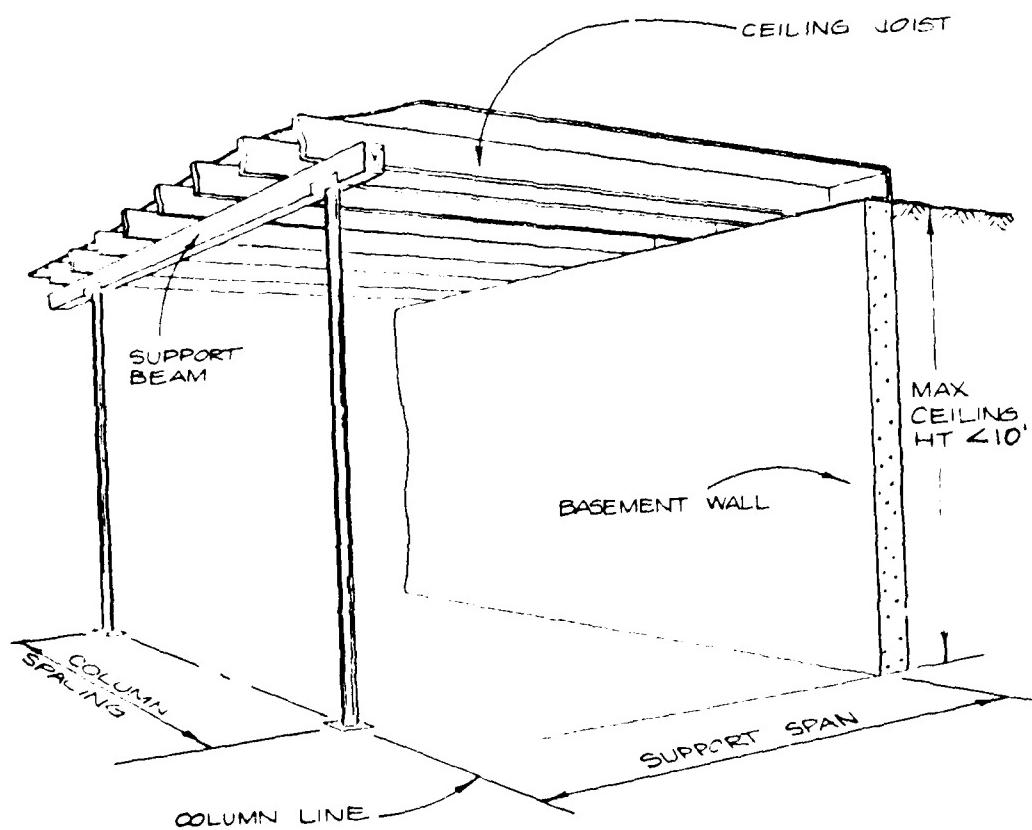


Fig. 2. Timber Joist and Beam Construction.

**Characteristics and Construction Details.**-- Ceilings are usually plywood or 2-inch thick tongue and groove lumber planks or decking, supported by joists that vary from 2x6 on 12-inch centers to 4x12 on 4-foot centers. Exterior joist supports are usually concrete or block masonry walls, while interior supports may be either steel or wood beams up to 12 inches in depth. Columns are wood posts or steel pipe. Spans between adjacent rows of supports normally vary between 6 and 18 feet. Upgrading commences with shoring to increase the load-bearing capacity to support the radiation protection (Figure 1).

**Shoring.**-- The recommended method for shoring the basic timber joist and beam structure shown in Figure 2 is to use either:

- (A) Stud wall upgrading, shown in Figure 3, or
- (B) Post and beam upgrading, shown in Figure 4.

The shoring should be spaced at midspan between rows of existing supports. (Drop ceilings will have to be removed.) Additional column supports must be placed at midspan between existing columns.

Figures 3 and 4 provide sufficient information to enable your representative to complete the checklists so that a detailed estimate of material, labor, and scheduling can be made.

## STUD WALL

### MATERIAL LIST

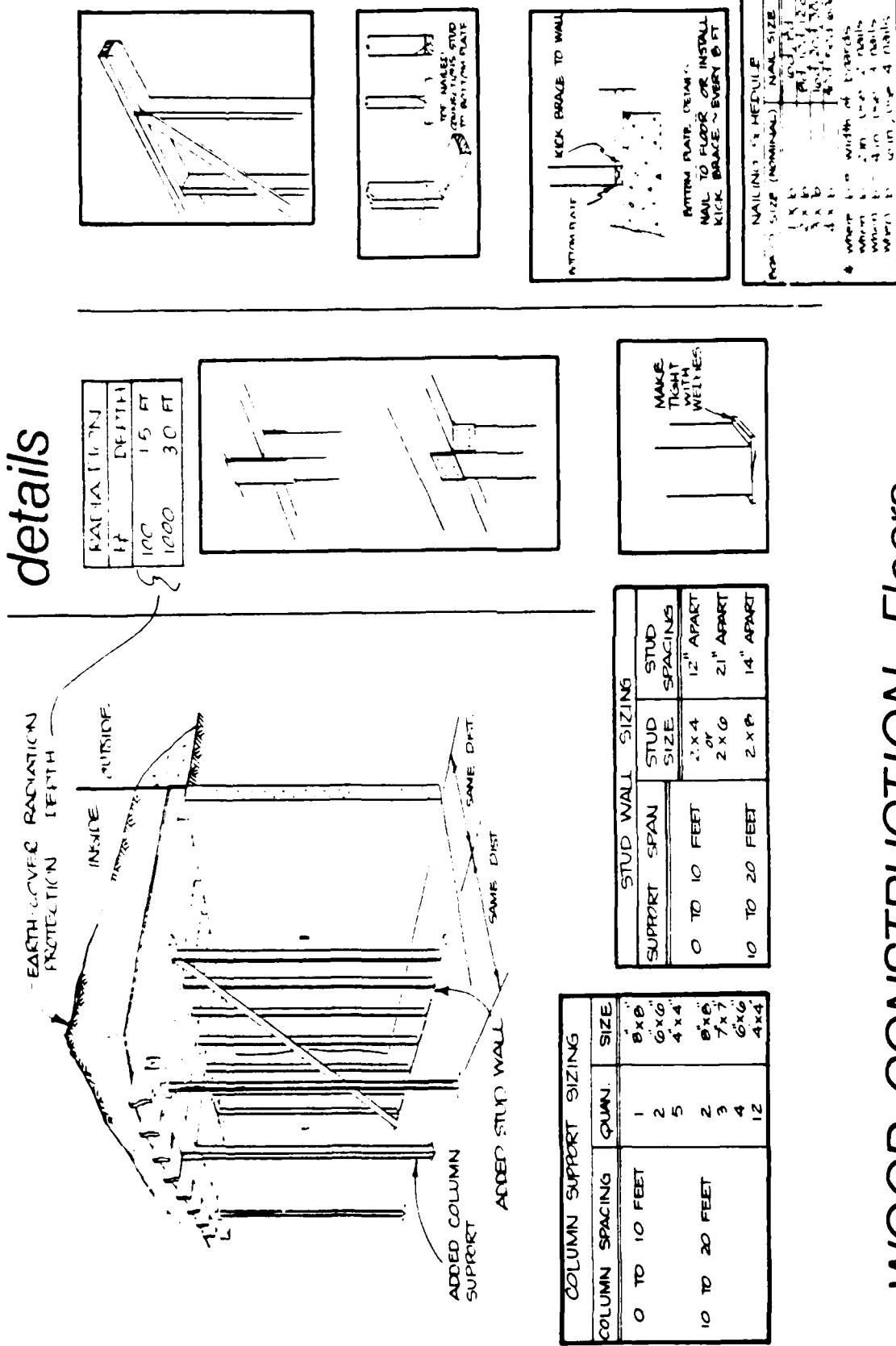
#### Required

#### Quantity

#### Available

1. Timber (Studs & Plates) \_\_\_\_\_
2. Bracing Material  
(Plywood Sheeting or  
nom. 1-in. Timber) \_\_\_\_\_
3. Nails \_\_\_\_\_
4. Hammer \_\_\_\_\_
5. Saw \_\_\_\_\_
6. Wedges \_\_\_\_\_
7. Tape measure/yardstick, etc. \_\_\_\_\_
8. \_\_\_\_\_
9. \_\_\_\_\_
10. \_\_\_\_\_

## details



# WOOD CONSTRUCTION - Floors

## TIMBER JOIST

Fig. 3. Stud Wall Upgrading.

**POST & BEAM**

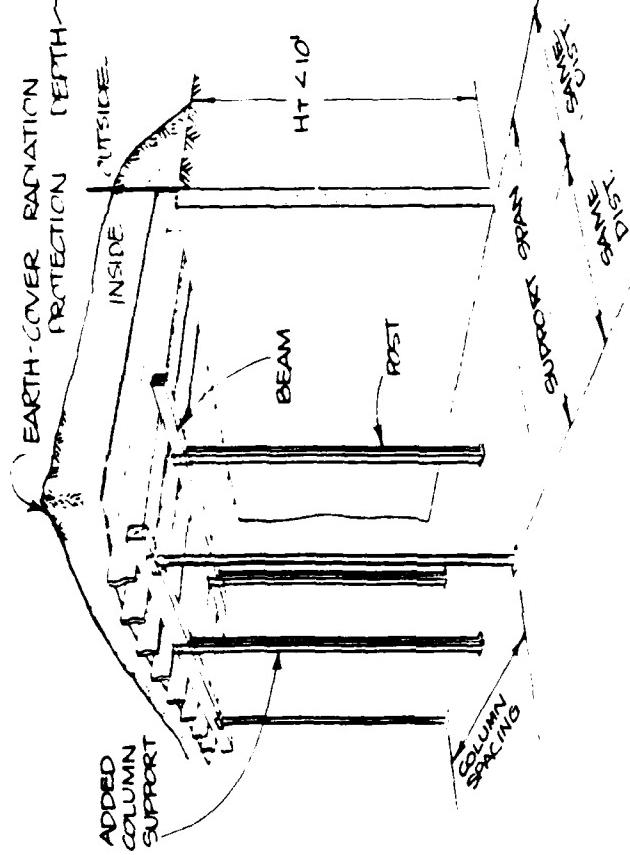
**MATERIAL LIST**

<u>Required</u>	<u>Quantity</u>	<u>Available</u>
1. Timber (Posts)		
2. Timber (Beams)		
3. Nails		
4. Hammer		
5. Saw		
6. Wedges		
7. Tape measure/yardstick, etc.		
8.		
9.		
10.		

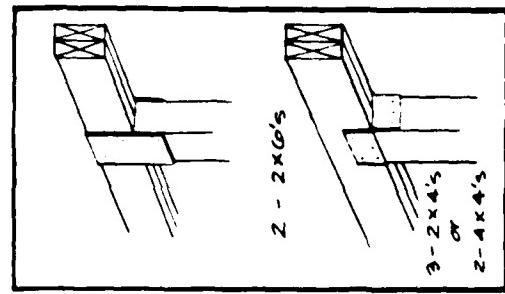
## WOOD CONSTRUCTION - Floors TIMBER JOIST

Fig. 4. Post & Beam Upgrading.

### details

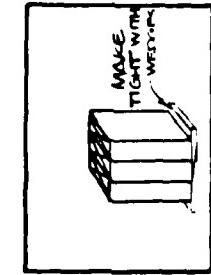


FOUNDATION	
1 F	1 EARTH
10"	15, FT
1,777	3,000



NAILING SCHEDULE	
BOARD SIZE (Nominal)	NAIL SIZE
1 X 6	10d x 1 1/2"
2 X 6	10d x 1 1/2"
3 X 6	10d x 1 1/2"
4 X 6	10d x 1 1/2"

\* Where b = width of boards  
when b = 2 in., use 2 nails  
when b = 4 in., use 3 nails  
when b = 6 in., use 4 nails



POST AND BEAM SIZING			
SUPPORT	SPAN	BEAM SIZE	POST SPACING
0 TO 10 FEET	1	6x6 6x6 4x4	2-2x6 3'-4'
10 TO 20 FEET	2	6x6 7x7 6x6 4x4	2-2x6 2x4's 10 TO 20 FEET 2-2x6 4x4's 3'

COLUMN SPACING	COLUN. QUAN.	SIZE
0 TO 10 FEET	1	6x6 6x6 4x4
10 TO 20 FEET	2	6x6 7x7 6x6 4x4

## **Task 5 Detailed Estimate of Material, Equipment, Labor, and Scheduling**

Use the data gathered on the Task IV checklists 1 and 2 to develop a materials and equipment list, and to determine the schedule to be met to prepare the shelter space to house your people and supplies.

You will need material and equipment for:

- (1) Shoring the floor above to hold two feet of earth (Figures 3 and 4)
- (2) Closures for all the windows, entrances, and other openings (Figures 7 through 10)
- (3) Covering the floor above with two feet of earth and to berm the outside walls to the same height (Figure 8).

The remainder of this section provides information needed for this task.

### **Shelter Closures**

The majority of shelter spaces will require some form of access-closure in addition to special closures to seal the spaces. Any basement upgraded for a Host Area shelter will probably have a stairway, windows, doors, ventilation ducts, or access openings.

These openings can be bridged by using a number of readily available materials, such as wood or steel. Examples of wood that may be used are fence posts, spare power poles (cut up), railroad ties, solid core doors, and wood beam and plank pieces. Steel plate and rolled beam sections may also be used. Table 3 lists alternative materials that may be considered for closures.

TABLE 3: CLOSURE MATERIALS

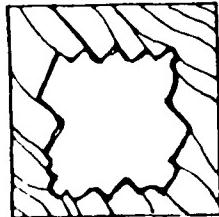
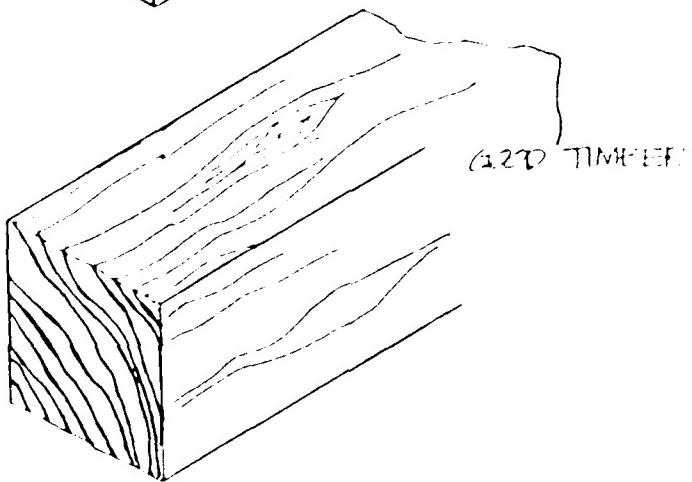
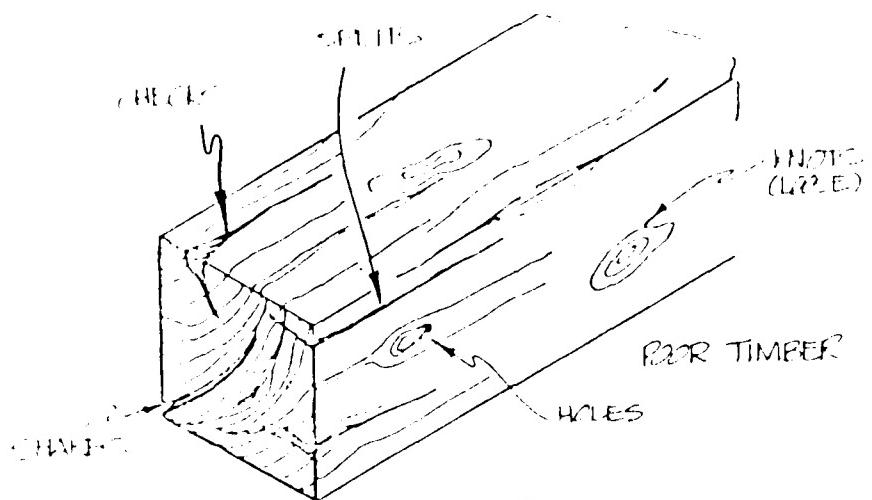
Steel doors	Telephone or power poles
Wood doors (solid)	*Filled sandbags
Toilet doors and partitions	*Filled paper bags
Steel cover plates	*Filled paper boxes
Desk and table tops	*Filled plastic garbage cans
Railroad ties	Brick or concrete block
Plywood	*Filled oil or paper drums
Wood, steel, or concrete fence posts	*Sand or earth

The use of wood products for closures requires that material variations affecting wood strength be considered. Wood fence posts, power poles, or railroad ties can be splintered or can exhibit rot or other defects. Generally, poor timber is utility grade when new, and may have loose knots or knotholes. Poor timber may have checks, shakes, or splits. These features are illustrated in Figure 5.

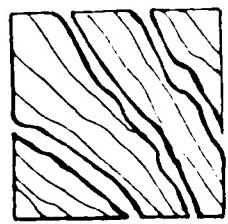
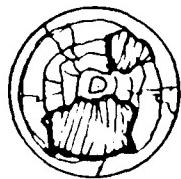
Comparison of various materials that may be used to construct closures is shown in Figure 6. This figure indicates the maximum opening width that may be spanned without intermediate support for various materials. This chart can be used in two ways:

1. Enter the chart with the minimum opening width, and list the type and thickness of materials that could be used for closures. The list could then be used to determine the most available materials.
2. Enter the chart with a known available resource and determine the width of closure that may be accommodated. This alternative will indicate if a further search for closure resources is required.

It must be remembered that all shelter closures also require radiation protection. The most straightforward approach is placing earth over the closure if



ROTTED TIES OR POSTS



SPLINTERED POSTS / POSTS TIES

Fig. 5. Factors Affecting Wood Strength.

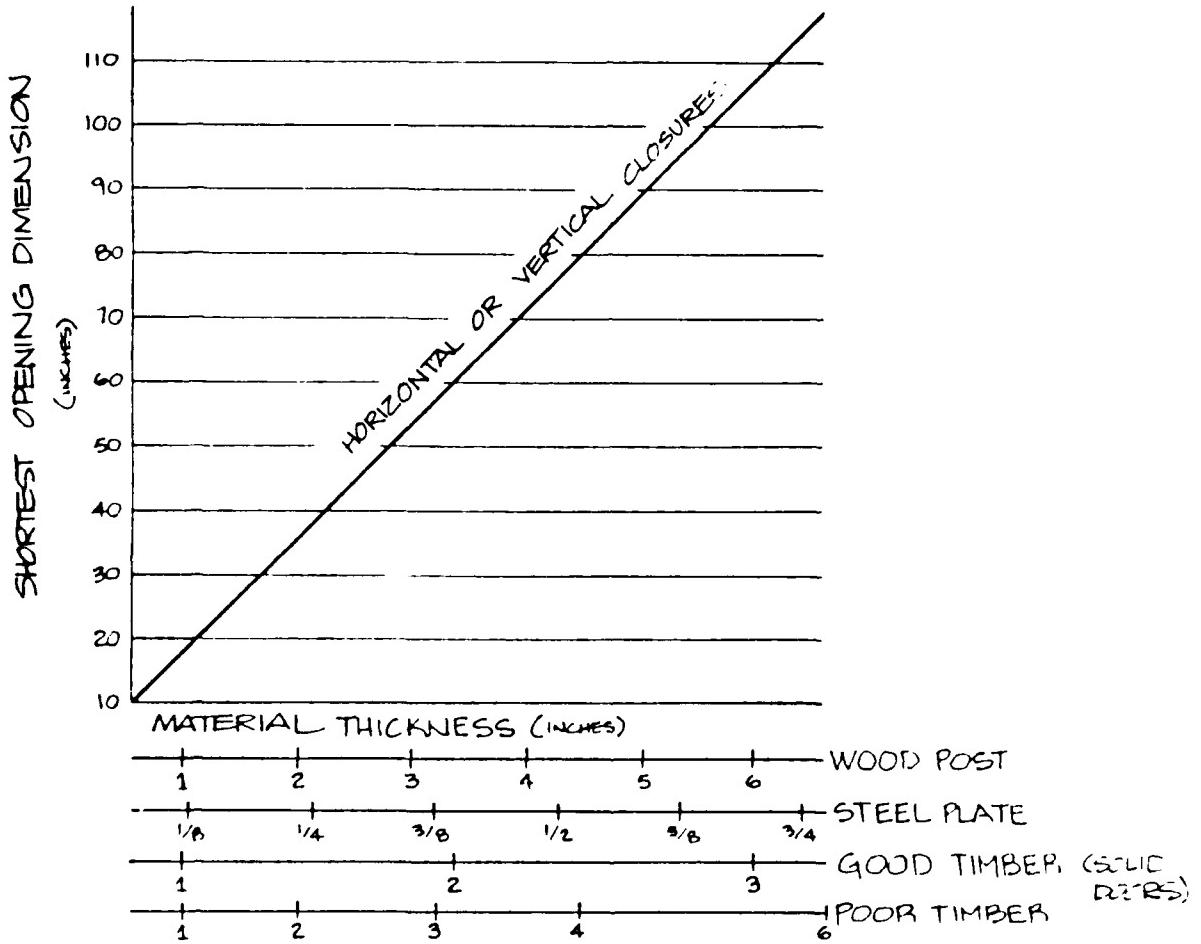


Fig. 6. Material Thickness Required to Close Various Openings (2 psi over-pressure).

it is horizontal, or piling earth against the closure if it is vertical. The earth placement may require significant personnel time or earth-moving equipment, particularly over basement floors enclosed by structural improvements. One expedient method is to place the earth (or sand) in containers such as sandbags, paper bags, cardboard boxes, or other containers.

Figures 7 - 10 illustrate different types of basement closures and placement of earth radiation protection.

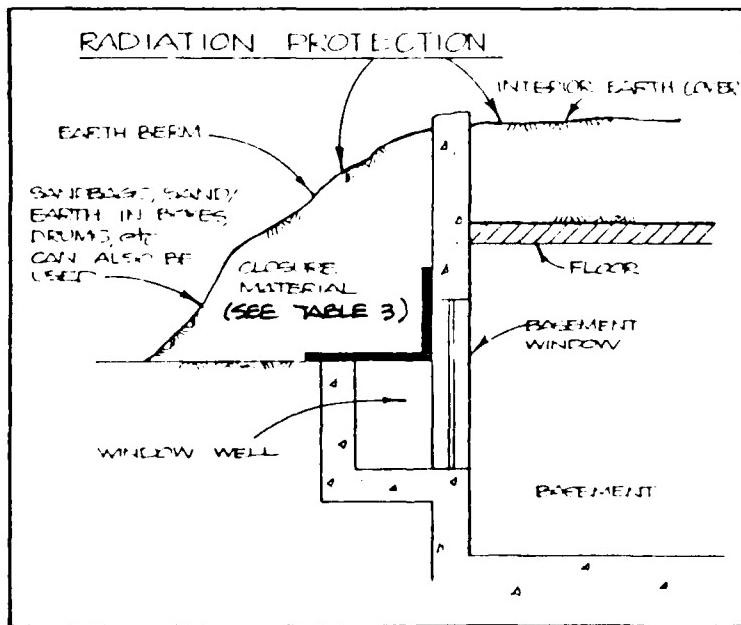
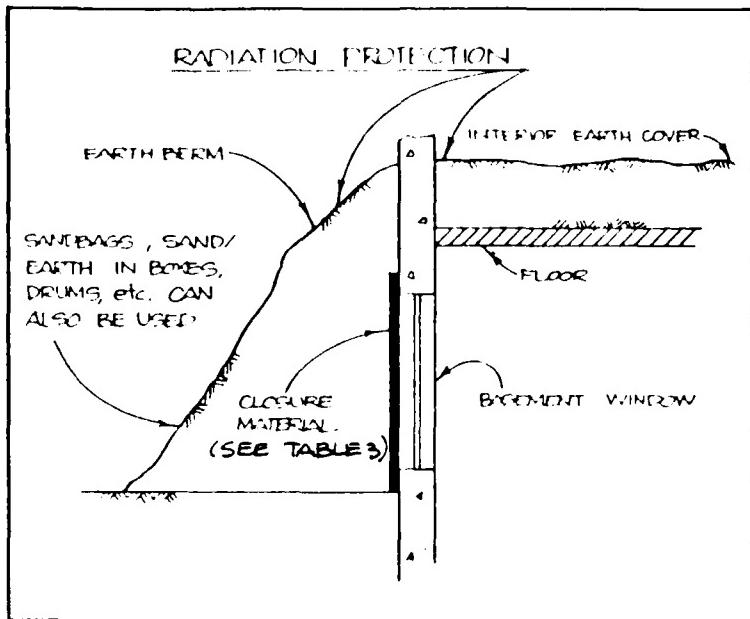


Fig. 7. Window Closures.

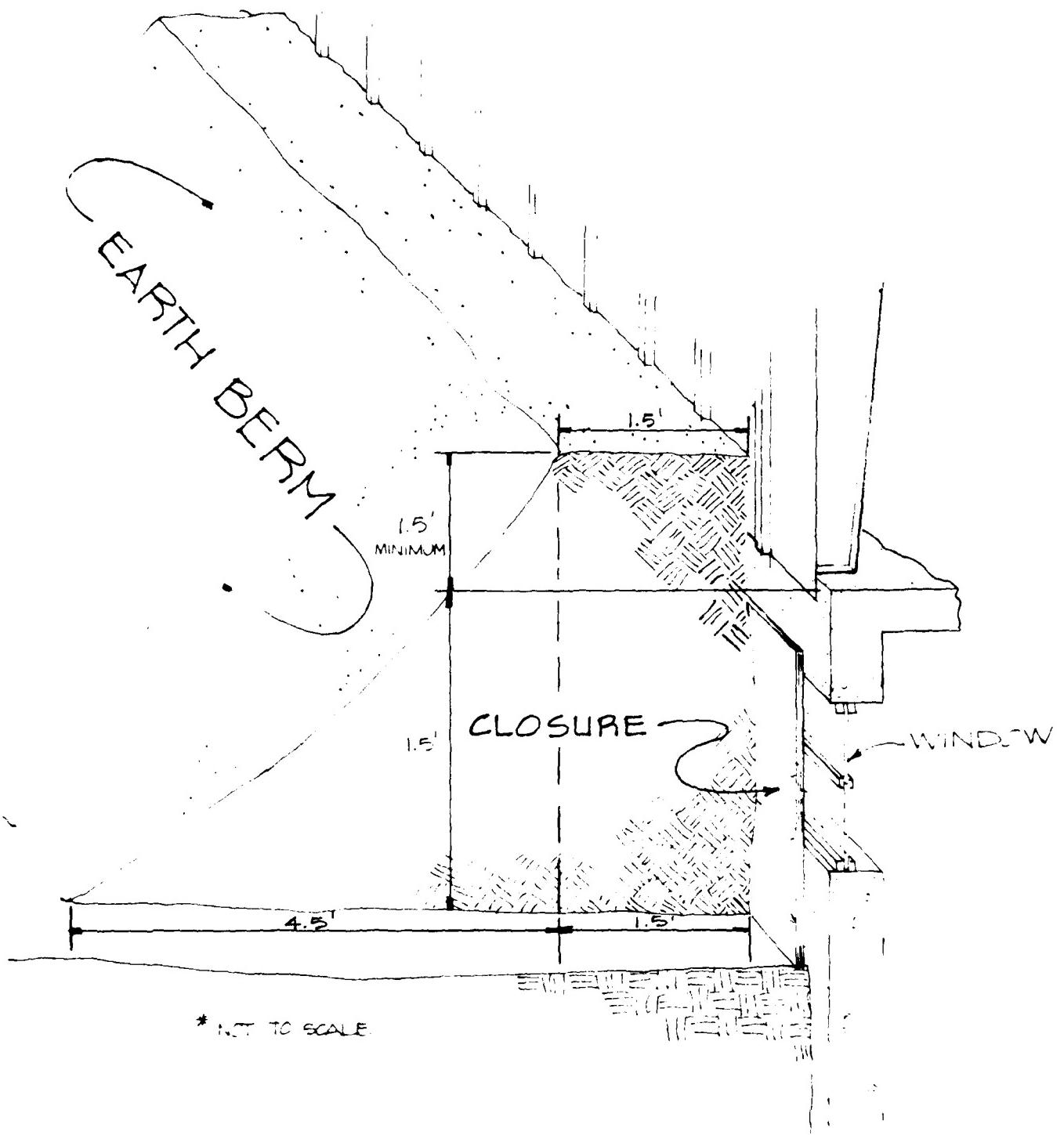


Fig. 8. Window Closure.

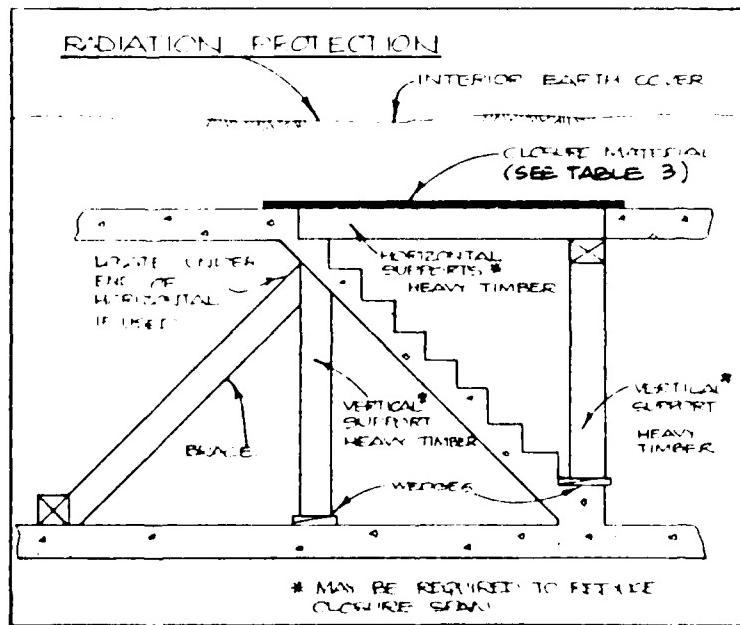
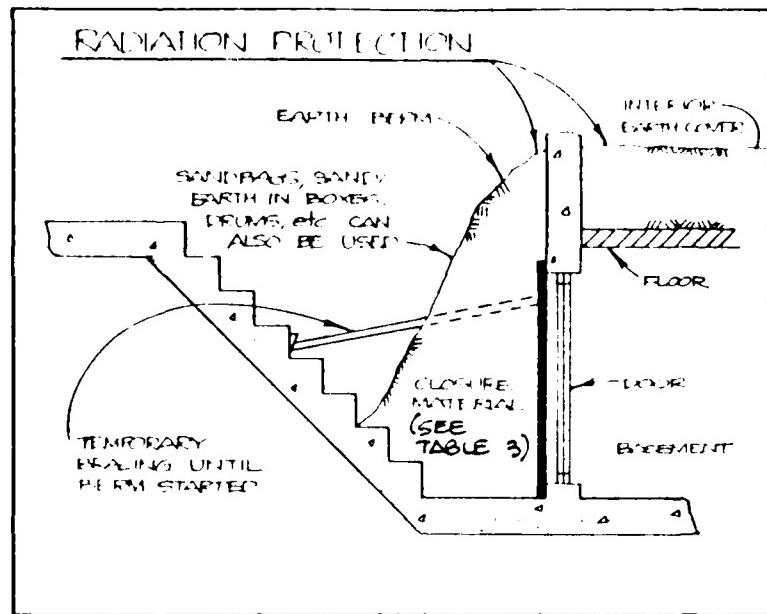


Fig. 9. Stair and Door Closures.

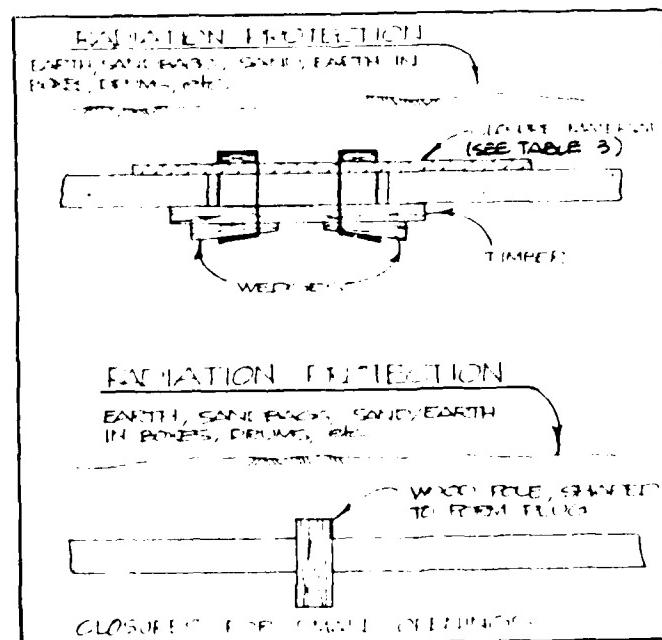
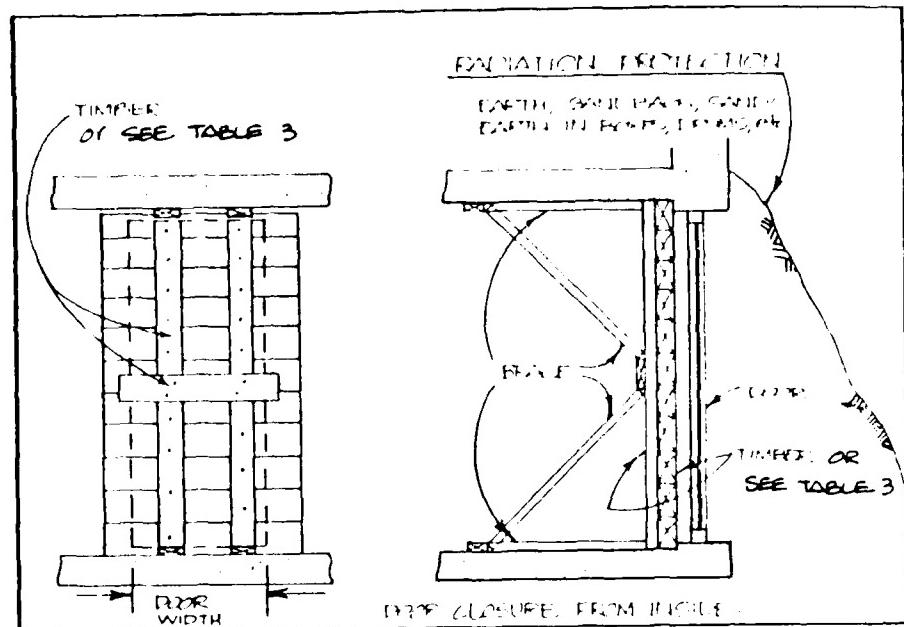


Fig. 10. Door and Small Opening Closures.

### Radiation Protection

The most readily available resource to protect a sheltered population against the long-term effects of radiation is a mass of earth. One and one-half to two feet of earth will provide a protection factor of 100.

Movement and placement of earth around the perimeter of a building area selected as a Host Area shelter may be a significant task. In order to provide an adequate estimate of time for earth radiation protection, Figures 11 and 12 are provided.

As an example, a 50-person basement shelter allowing 25% of shelter space for stocking and supplies can be analyzed as follows:

50 person x 10 sq ft x 1.25 = 625 sq ft of area, or  
a shelter 25 feet square.

625 sq ft x 2 ft deep : 27 = 46 cubic yards.

Using Figure 11 and assuming the dimensions of the exterior earth berm shown in Figure 8:

$3 \times 1.5 + 3 \times 4.5 : 2 = 11.25 \text{ ft}^3 \text{ per foot of berm,}$   
 $\text{or } 0.42 \text{ yd}^3 \text{ per foot of berm}$

If berthing is required on two sides of the shelter,

$0.42 \text{ yd}^3 \times 2 \times 25 = 21 \text{ cubic yards.}$

Thus, a total of 46 + 21, or 67, cubic yards of earth is required. Placement of this material by hand labor would take 24 man-hours of time, or three men for an 8-hour workday (Figure 11). For larger shelters or shelters where equipment may be used to place the earth radiation protection, Figure 12 may be used.

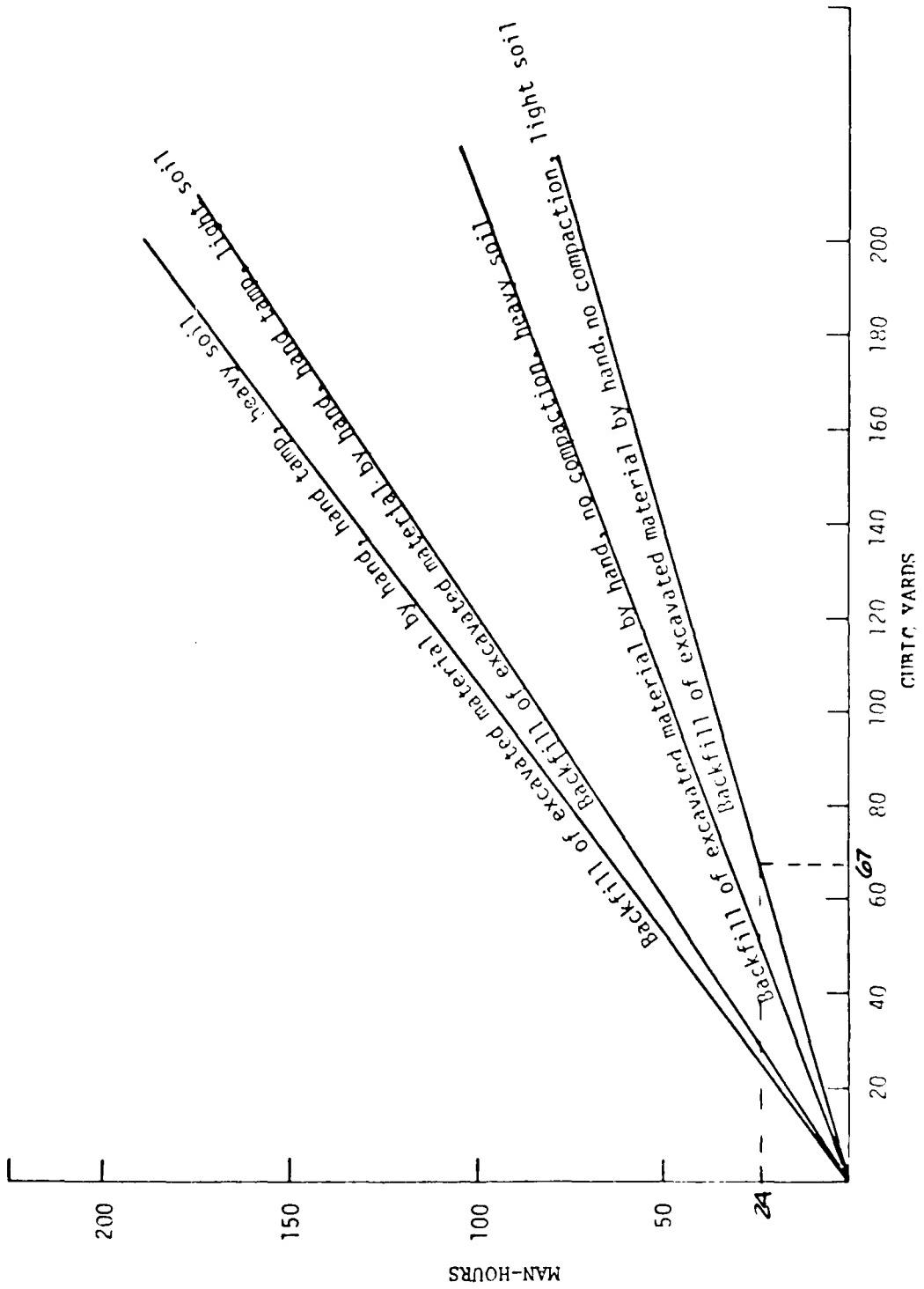


Fig. 11. Time Requirements for Hand Earth Moving Processes.

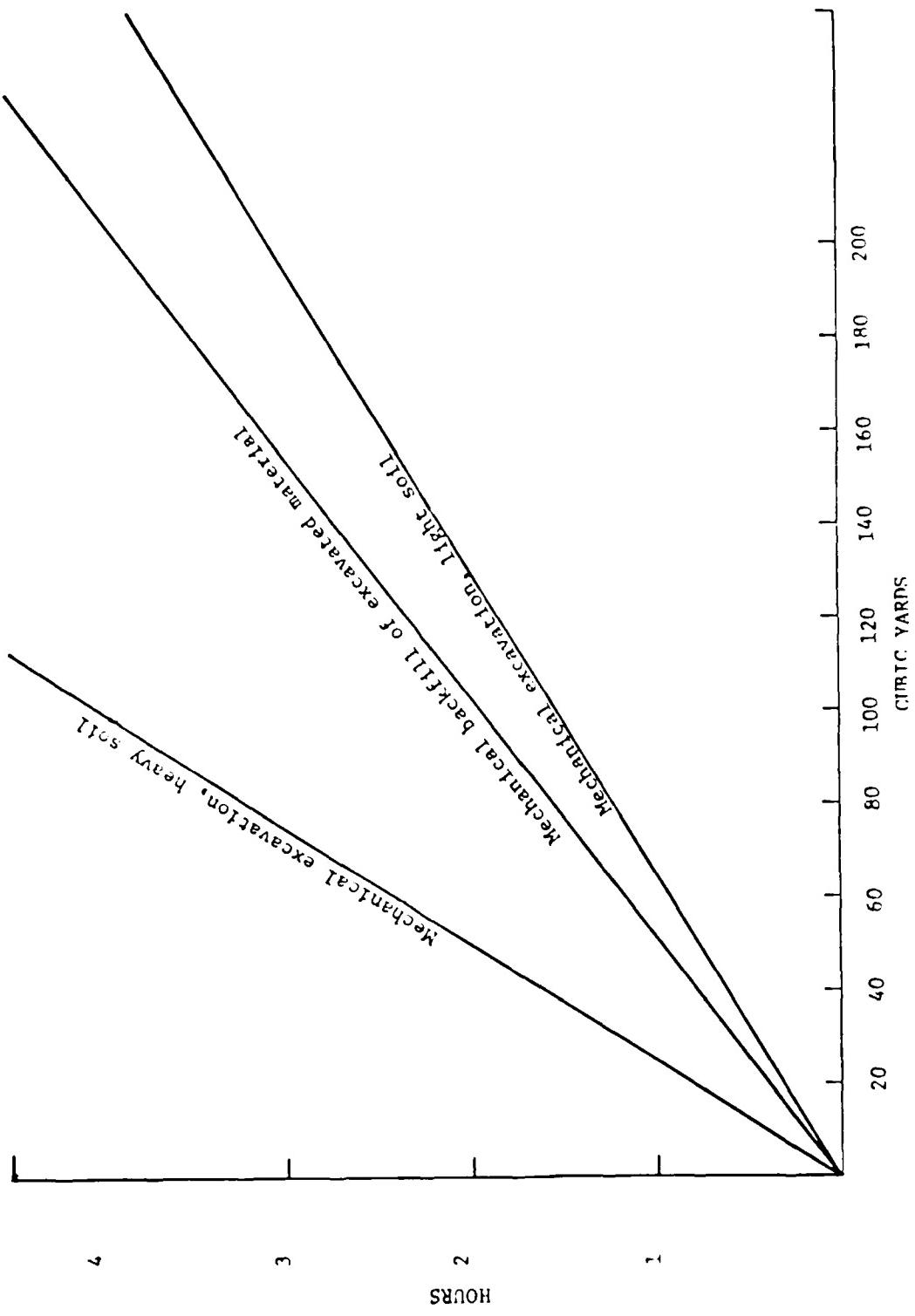


Fig. 12. Time Requirements for Mechanical Earthmoving Processes.

### **Task 6: Logistics Preparation and Upgrading Sequence**

The planning and analysis in Tasks 1 through 5 have provided for selection of upgradable shelter space and data on available resources and supplies for upgrading. This planning has provided:

- o An evaluation of the shelter(s) assigned and/or selected to determine upgrading methods and resources needed.
- o Shelter stocking lists based on shelteree numbers and needs.
- o Upgrading development methods for preparing various alternative shelters.

### **Manpower Assignments**

Each industry providing a Host Area shelter plan for its employees should assign personnel to shelter tasks based on their experience in expediting projects and providing alternate solutions to problems as they arise. Shelter preparedness will require a team of supervisory industry personnel to accomplish the upgrading, stocking, and movement to shelter. A pre-assigned management organization can best implement the development of Host Area shelters.

### **Upgrading Sequence for Post-Warning Implementation**

Upgrading of shelter space, whether an existing basement or expedient structure, requires an organized sequence of steps to implement efficiently (i.e., time and resources) after warning of an impending attack.

- o The shelter coordinator should provide maps and sketches of the Host Area site to all other shelter team personnel.
  - (1) A detailed road map to direct people to the Host Area shelter site.
  - (2) A site sketch sheet showing the shelter location at the site, with address, etc.
  - (3) A building sketch sheet showing where the shelters are within the confines of the shelter site.

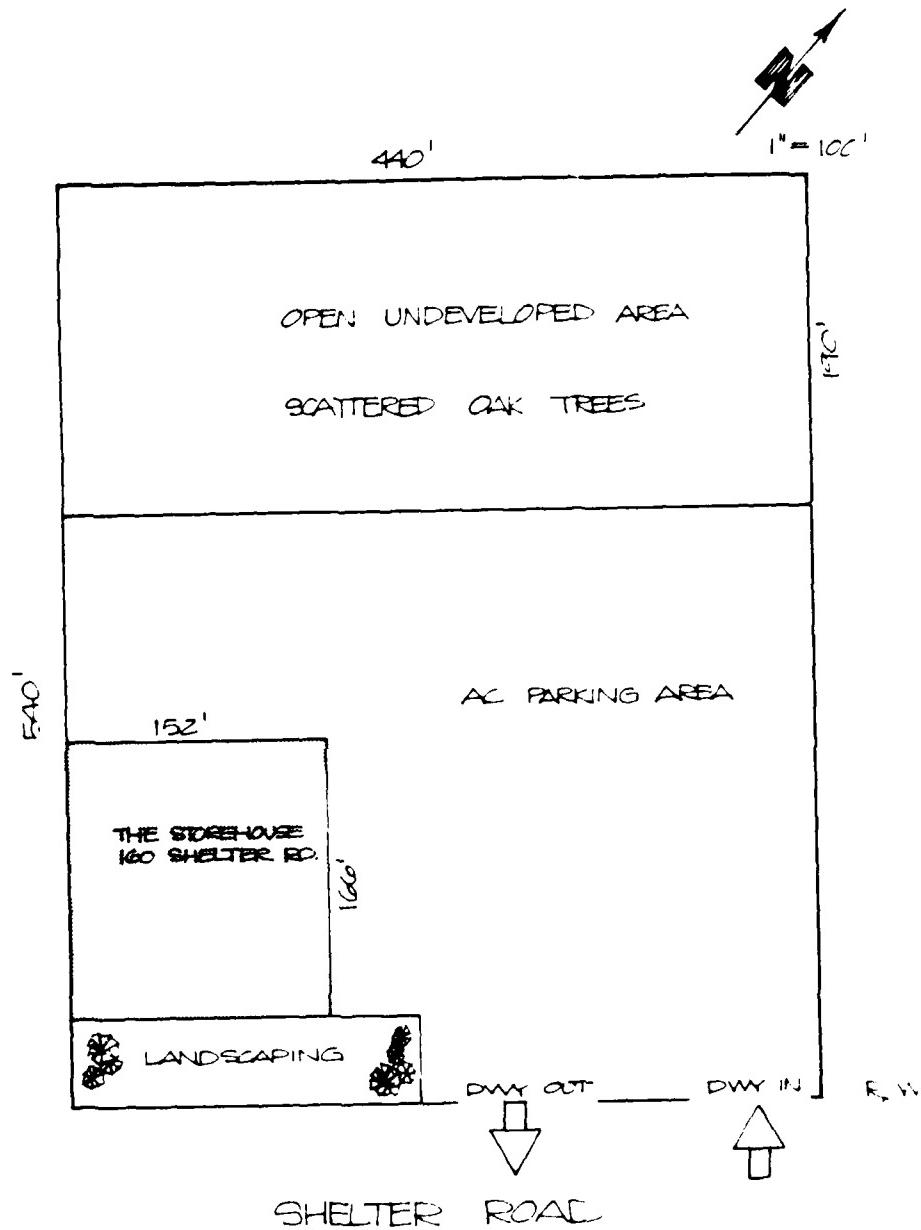
Suggested examples of the site sketch sheet and the building sketch sheet are enclosed.

- o The shelter manager in conjunction with other team members should complete the following checklists:
  - (1) **Checklist 1.**-- Equipment and Resources for Upgrading; acquire resources if not already available.
  - (2) **Checklist 2.**-- Upgrading Sequence Priority Time Frame Analysis.
  - (3) **Checklist 3.**-- Expedient Shelter Option Burial Priority Time Frame Analysis. (To be used only if expedient shelter option is selected. See Appendix A.)

Note: Shelter preparation and upgrading (Checklists 2 and 3) are designed to be completed within the 72-hour time frame. If the total elapsed time exceeds the 72-hour time frame: (1) the shelter upgrading development plan may need to be re-assessed; or (2) more personnel, equipment, or resources may be needed, to reduce the total elapsed time to less than 72 hours. The lower the total elapsed time, the better off the sheltered population.

### SITE SKETCH SHEET

FACILITY NUMBER 27T4 DATE 3-1-80  
BUILDING NAME THE STOREHOUSE SURVEYOR 22

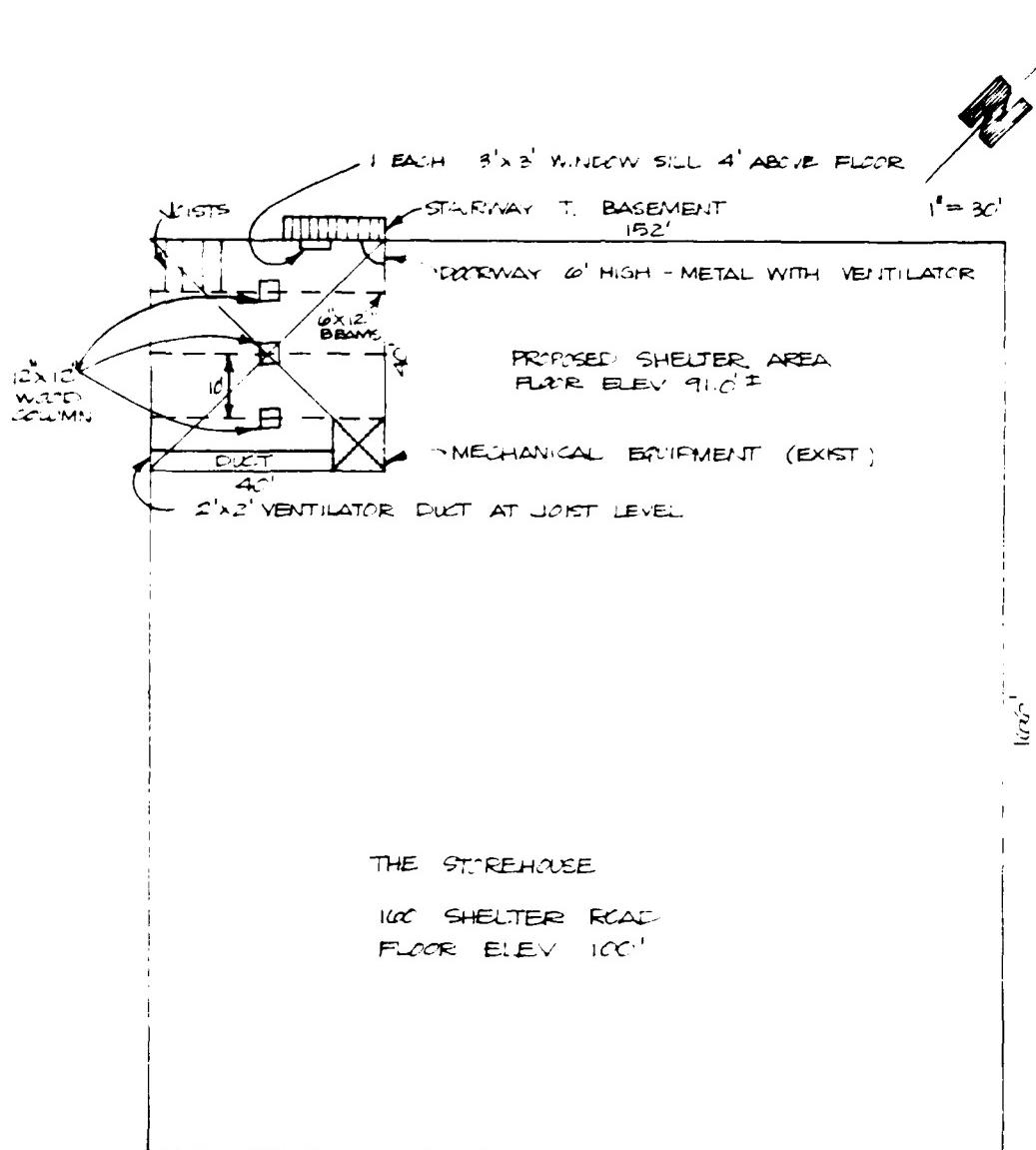


N. Arrow  Distance to Soil 20' Mut. Shielded Wall No  
Access Obstructions NONE Changes in grade 1' ± Frontage Rd. YES

BUILDING SKETCH SHEET

FACILITY NUMBER 27TA  
BUILDING NAME THE STOREHOUSE

DATE 3-1-80  
SURVEYOR 22



N. Arrow v Ext. Wall Mat. CONC BLOCK Ext. Wall Height 6' ±  
Aperture Dim. sill/height/width Roof Slope N/A Roof Mat. N/A  
Detail Beams 6x12" Joist Location & Dim. 2" x 10"  
1st Flr Elev. +1' Roof Overhang 3' Joist O.C. 16" Joist Span 10'  
First Floor Mat. 2" T&G Second Floor Mat. N/A Basement CONCRETE

HOST AREA SHELTERS

TASK VI EQUIPMENT AND RESOURCE CHECKLIST 1

Item	Amount Needed	Amount Available	Amount to Obtain
Portable generator with fuel	1 each		
Portable lights with cords	3 to 4 each		
Power saws with cords	2 or more		
Wheelbarrow	2 or more		
Pick & Shovels	many		
Hammers	many		
Nails & Hardware	From Task IV		
Measuring and mark- ing equipment	3 sets		
Handsaw	3 or more		
Misc. jacks, clamps, hardware			
<u>Lumber*</u>	From Task IV Mater- ials List: (Enter quantity)		
2 x 4			
2 x 6			
1 x 4			
1 x 6			
4 x 6			
4 x 4			
Wood wedges (pairs)			
1/2" Plywood 4' x 8' sheets			
5/8" Plywood 4' x 8' sheets			
3/4" Plywood 4' x 8' sheets			
<u>Other Needs</u>			

\* Linear feet unless otherwise indicated.

HOST AREA SHELTERS

TASK VI CHECKLIST 2

UPGRADING SEQUENCE PRIORITY CHECKLIST	ESTIMATED TIME FRAME		
	EQUIPMENT NEEDED	EQUIPMENT TIME	MANHOURS REQUIRED
		NO OF PERSONNEL	TOTAL TIME USED-HOURS
1) Obtain resource list, resources - move to shelter for upgrading.	Trucks		
2) Remove debris, clean shelter & surrounding area.	Trucks & Tools		
3) Lay out upgrading (shoring, closures, radiation protection), make initial checks of materials, cut materials and check fit.	Power tools Hand tools & Supplies		
4) Complete upgrading including entry structures.	"		
5) Complete movement of earth for radiation protection.	Dozers, Loaders Wheelbarrows Buckets, Shovels etc.		
6) Start ventilation equipment installation	Power tools Hand tools & Supplies		
7) Install interior shelter features - toilets, shelves	Power and Hand Tools		
8) Clean up & stock shelter with all food and supplies	Misc. Hand Tools		
9) Provide for waste disposal area.	Misc. Excavation Tools		

HOST AREA SHELTERS

TASK VI CHECKLIST 2

UPGRADING SEQUENCE PRIORITY CHECKLIST	EQUIPMENT NEEDED	EQUIPMENT TIME	MANHOURS REQUIRED	NO OF PERSONNEL	ESTIMATED TIME FRAME	TOTAL TIME USED-HOURS
10) Implement Shelter management program.						
11) Expedient shelter burial if not completed previously (from Checklist 4). Eliminate Item 5 above.						
					TOTAL ELAPSED TIME ≤	72.0 hrs.

### TASK VI CHECKLIST 1

#### HOST AREA SHELTERS

EXPEDIENT SHELTER OPTION BURIAL PRIORITY	EXPEDIENT SHELTER ESTIMATED TIME FRAME		
	EQUIPMENT NEEDED	EQUIPMENT TIME	MANHOURS REQUIRED
		NO OF PERSONNEL	TOTAL TIME USED-HOURS
1) Provide transportation and personnel to move expedient shelter location.	Trucks, Cranes, Forklifts		
2) Obtain equipment and excavate for burial, partial burial or berms, including entries.	Backhoes, Bulldozers, Front Loader		
3) Provide modification to structure for entry holes for ventilation and access of shelterees.	Special tools and equipment		
4) Place shelter in excavation, install entry, ventilation and appurtenant items such as floors.	Cranes or other lifting equipment		
5) Install large shelter stock items and backfill and berm structure.			
			TOTAL ELAPSED TIME *

\* Transfer to Item 11 Checklist 2 if not completed prior to D-Day minus 3.

## **SUMMARY**

This manual provides a procedure to develop shelter space that involves coordination in planning and conversion of commercial space in use in another community. The conversion must provide adequate, livable shelter space within a 72-hour time frame. Some industries may prefer to choose their own shelter area and locate it on private property, perhaps where there are no structures at present. Appendix A provides information for this alternative. Appendix B provides data on shelter management.

The time is D-day minus 3, your industry has just received a 72-hour warning to complete evacuation and preparation of a shelter for a two-week stay. Are you prepared to do it?

## **GLOSSARY AND LIST OF NOTATIONS**

- AS BUILT** — Structure prior to upgrading
- UPGRADING** — Strengthening of a structure to withstand unusual (larger than normal) loads
- BLAST WAVE** — A wave of sudden pressure change that moves outward from an explosion, creating larger than normal loads
- OVERPRESSURE** — The sudden pressure change caused by a blast wave, measured in psi. One psi is equivalent to a column of water 2.3 feet high or a column of soil 1.4 feet high
- RISK AREA** — Region that is subjected to blast pressures over 2 psi
- HOST AREA** — Region that is subjected to blast waves with pressures of 2 psi or less
- HOST AREA** — A shelter that will protect the inhabitants  
**SHELTER** — to 2 psi or better (equivalent to a column of water 4.6 feet high, or a column of soil 2.3 feet high)
- P<sub>f</sub>** — Protection Factor (radiation). A number that indicates how many times less severe the effect of radiation is in a shelter than that received when there is no protection
- PSF** — Pounds per square foot (an indication of pressure loading; a one-foot thick layer of soil would apply a pressure of about 110 psf)
- PSI** — Pounds per square inch (144 psf = 1 psi)

**APPENDIX A**

**ALTERNATIVES TO CIVIL DEFENSE ASSIGNED SPACE  
EXPEDIENT SHELTER OPTIONS  
SHELTER ENTRY AND CLOSURES FOR UNDERGROUND SHELTERS**

This is an alternate Booklet 3  
for the case of no  
Host Area assignment

## **ALTERNATIVES TO CIVIL DEFENSE ASSIGNED SPACE**

- o Select a host area for evacuation of your industry personnel and their families. The Host Area should be in a rural environment located away from large, industrialized urban areas, military installations, or seats of government. If you do not already have access to a suitable location, poll friends, relatives, business associates, as well as employees. (Perhaps you can exchange the capabilities you bring for access, or agree to assign the shelter and all the improvements to the host for his own use after the crisis and its associated fallout environment have subsided to safe levels.)
- o Determine if upgradable space is available, such as a basement building area that is of sufficient size and that may be upgraded to shelter all personnel.
- o Select an alternative expedient shelter if upgradable space is unavailable. (See checklist pages 3 and 4)
- o Develop upgrading methods, and obtain all resources and equipment needed to implement the scheme.
- o Provide shelter stocking resources, develop logistics for resources, based on shelter requirements.

## **EXPEDIENT SHELTER OPTIONS**

Existing basement structures may be limited in some designated Host Areas. It will be necessary in these situations to use expedient shelters. There are a number of options to be considered, including adapting host area in-place facilities such as tanks, storm drains, utility vaults, or alternatively obtaining semi-portable structural facilities for use as buried shelters. Options that can be buried and used as shelters include railroad cars, maritime shipping containers, and other specially built modular structures. Table A-1 lists options that may be implemented without upgrading, and Table A-2 lists options that require some form of upgrading. The upgrading method recommended is post and beam, since it provides the most efficient use of shelter space.

Expedient shelter options discussed and data presented are as follows:

Buried tanks	page A-7
Railroad Cars	page A-8
Storm drain systems	page A-12
Other shelter types	page A-17

Expedient shelter fact sheets are provided for each option to help in selecting and implementing the options for shelters. At the end of this section an estimate of preparation time for some of the expedient options is provided (Table A-4, page A-27).

The shelter options discussed herein are just a few of the potential possibilities for Host Areas. Each plant superintendent and/or industry planner should conduct a survey that will provide him the best shelter choice. The formation of mutual aid pacts with nearby industries or suppliers to jointly develop Host Area shelters also should be considered.

## HOST AREA SHELTERS

### EXPEDIENT SHELTER OPTION CHECKLIST

(Refer to following pages for various options)

- 1) Is a suitable site available? \_\_\_\_\_
- 2) Is an expedient shelter available? \_\_\_\_\_
  - a) Existing buried structure - Onsite \_\_\_\_\_  
Adjacent off site \_\_\_\_\_
  - b) New option to be buried: Tank \_\_\_\_\_  
Railcar \_\_\_\_\_  
Vault \_\_\_\_\_  
Container \_\_\_\_\_  
Other \_\_\_\_\_
- 3) Transportation to site - Easily relocated \_\_\_\_\_  
Special transportation required \_\_\_\_\_
- 4) Type of transportation equipment needed:
  - (a) \_\_\_\_\_
  - (b) \_\_\_\_\_
- 5) Space upgrading - Length \_\_\_\_\_ Width \_\_\_\_\_ Height \_\_\_\_\_
  - a) Type of upgrading - Post & Beam\* \_\_\_\_\_
  - b) Number of exits, windows, and other passages for closures required? \_\_\_\_\_

Dimensions: \_\_\_\_\_ x \_\_\_\_\_  
\_\_\_\_\_ x \_\_\_\_\_  
\_\_\_\_\_ x \_\_\_\_\_  
\_\_\_\_\_ x \_\_\_\_\_

\* Post and beam upgrading of expedient shelters will allow a more efficient use of shelter space.

EXPEDIENT SHELTER OPTION CHECKLIST (contd)

c) Ventilation equipment

Is shelter space adequately ventilated? \_\_\_\_\_

Can shelter space be adequately ventilated? \_\_\_\_\_

Are ventilation resources available? \_\_\_\_\_

6) Upgrading resources

a) Are lumber and other materials available for upgrading? Yes \_\_\_\_\_ No \_\_\_\_\_  
Locally? \_\_\_\_\_

b) Are tools and equipment available for upgrading? \_\_\_\_\_  
Locally? \_\_\_\_\_

7) Is burial site available? \_\_\_\_\_

a) Is potential debris pileup a problem? \_\_\_\_\_

b) Is high ground water a problem? \_\_\_\_\_

8) Is secure storage for resources, materials and tools available? \_\_\_\_\_

TABLE A-1

## POTENTIAL HOST AREA SHELTERS THAT WITHSTAND 2 PSI WITHOUT UPGRADING

Shelter Option Description	Where to Locate, Whom to Contact
<b>Cylindrical tanks</b>	Look in Yellow Pages of telephone book for: (1) Tanks, Metal; (2) Tanks, Used; (3) Tanks, Fiberglass; (4) Tanks, Repairing; (5) Tank Lining and Coating.
<b>Surplus Railroad Cars</b>	Obtain from railroad equipment and supply company. For example, the Purdy Company sells surplus rail cars and equipment.
<b>Storm Drainage Facilities</b>	City and county public works departments and flood control districts. U.S. Geological Survey topographical maps and other special purpose maps (not road or street maps.)
<b>Mine Shafts and Tunnels</b>	U.S. Geological Survey geologic maps. State Division of Mines publications. Road and rail maps
<b>Other Options</b>	
Concrete Utility Vaults	Concrete products manufacturers in Yellow Pages.
Reinforced Concrete Pipe	Yellow Pages under Concrete Pipe Products, Culverts, Manufacturers and Pipe.
Concrete Tanks	Yellow Pages under Tanks — Concrete.

- 
- \* Box culverts and tunnels require extensive closure systems to prevent longitudinal entry of blast effects. (Two psi won't endanger occupants directly, but can shatter glass.) It is suggested culverts and tunnels be fitted with 40 psi blast doors as the shelter itself is likely to be able to survive this pressure.

TABLE A-2  
POTENTIAL HOST AREA SHELTERS THAT REQUIRE UPGRADING

Shelter Option Description	Where to Locate, Whom to Contact	Upgrading Method
<b>Surplus Railroad Cars</b>		
Caboose	Obtain from railroad equipment and supply company. For example, the Purdy Company sells surplus	Post and Beam Lateral span
Passenger		Plywood sheathing
<b>Other Options</b>		
Surplus Maritime Shipping Containers	Container manufacturing and repair companies; obtain from Containerization International Yearbook	Post and Beam Lateral span
Trailer, Truck Van Bodies	Yellow Pages under Truck Bodies and Truck Equipment and Parts.	Post and Beam Lateral span
Metal Newspaper Storage bins	Look in Yellow Pages under Waste Paper	Post and Beam Lateral span

## EXPEDIENT SHELTER FACT SHEET BURIED TANKS

Buried tanks provide ideal Host Area Shelters. A typical installation is shown in Figure A-1.

- (1) Any steel tank newly manufactured and unused that is ordinarily buried.
- (2) Any other types of new non-pressure tanks such as fiberglass fuel tanks or septic tanks.

### Limitations

- (1) Do not use tanks that have been previously used for fuel storage, toxic chemicals, or other hazardous materials.
- (2) Do not bury tanks in areas of high ground water, as tanks may rise out of ground owing to fluid uplift.

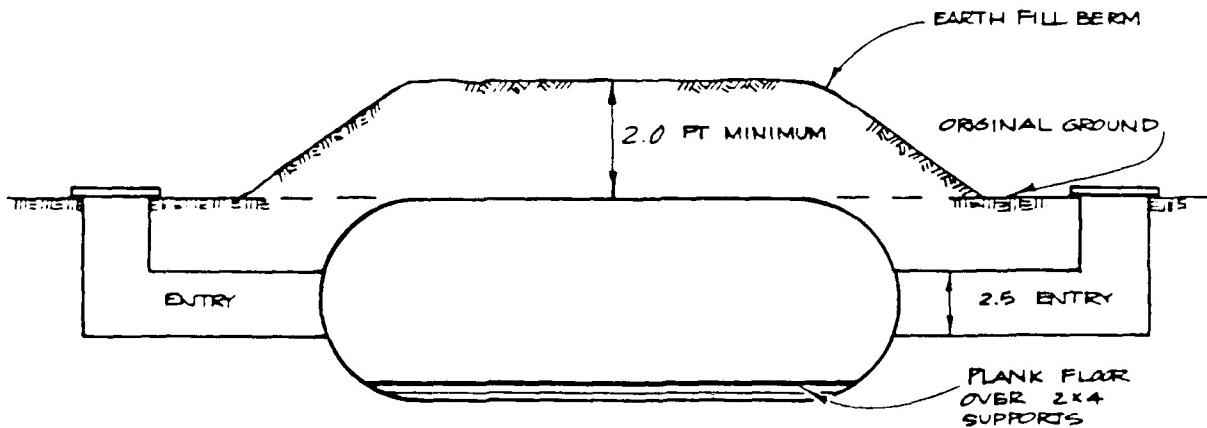


Figure A-1. Typical Installation (Any Buried Tank)

Note: Entry can be fabricated using 30-inch diameter corrugated metal, concrete pipe, or wood framing. See Shelter Closures in this Appendix.

## EXPEDIENT SHELTER FACT SHEET RAILROAD CARS

Certain types of railroad cars can provide ideal Host Area shelter space without upgrading. Other types require minor upgrading. The railcar options discussed are limited to these types:

- o Box cars and refrigerator cars require no upgrading.
- o Caboose and passenger car types require post and beam upgrading with closures on windows and other openings.

### **General Notes**

- (1) All cars would have their undercarriages, couplers, and miscellaneous non-essential frame materials removed.
- (2) Refrigerator cars have access hatches on the top. Thus, access and ventilation can be provided using the hatches, whether the cars are buried upright or on their sides.
- (3) Box cars require access and ventilation holes to be cut through the sides or ends of the cars, or modifications made to existing access doors.
- (4) Caboose and passenger cars will require closures over existing window areas to prevent blast damage, even at 2 psi.
- (5) The upgrading scheme best suited to railcars is post and beam type (see Fig. A-10) since more efficient space utilization occurs.
- (6) Heavy capacity lift equipment is required to place cars in an excavation.

### **Advantages of Implementing Railcars**

- (1) They are numerous. See Table A-3.
- (2) Railcar types suggested for expedient shelters are all constructed with steel frame exteriors. Steel or wood interiors vary with car type.

TABLE A-3. TYPICAL ANNUAL RAILCAR AVAILABILITY

Type of Car	Total No. of Cars Retired Annually	10% of Car Bodies Usable Without Repair	20% of Car Bodies Estimated Repairable	Total Potential Car Bodies Usable	Estimated Total People Sheltered
Box	34,600	3,460	6,920	10,380	207,600
Refrigerator	960	96	192	288	5,700
Caboose	960	96	192	288	4,300
Passenger	450	45	90	135	4,000
Total Cars	<u>36,970</u>	<u>3,697</u>	<u>7,394</u>	<u>11,091</u>	<u>221,600</u>

Details of buried railcar shelters are shown on the following pages.

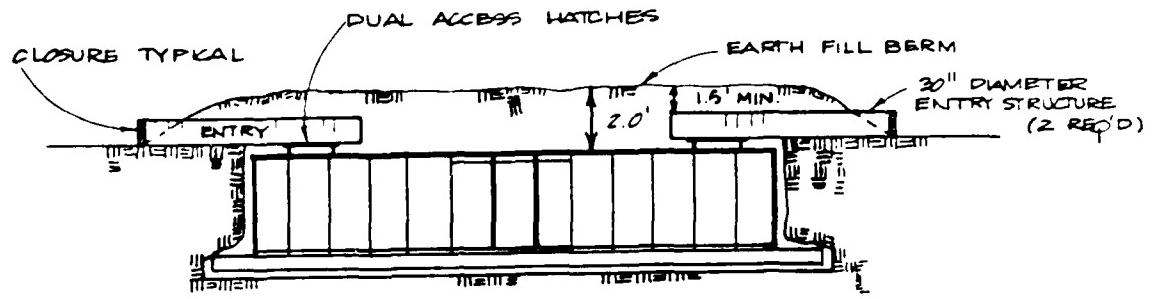


Figure A-2. Typical Buried Refrigerator or Box Car.

**Notes:**

- (1) Railcar undercarriage and miscellaneous frame components to be removed prior to burial.
- (2) Access to hatches to be fabricated of 30-inch metal pipe or wood framed. Double entry to compartment hatches for ventilation is recommended. Alternate entry may be provided through side of car.
- (3) Entrance closures are required for radiation protection (Figs. A-16 to A-21).
- (4) Cars are to be cleaned prior to burial.

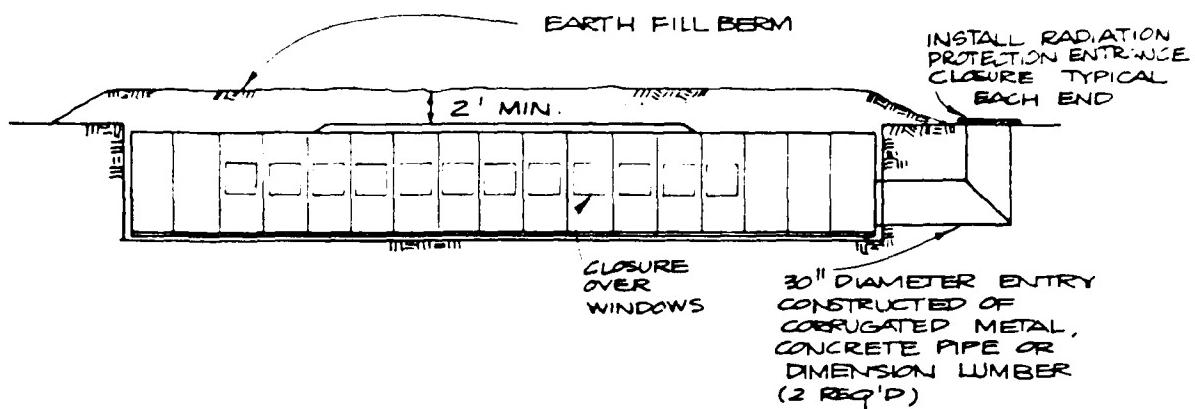


Figure A-3. Typical Buried Passenger Car or Caboose.

**Notes:**

- (1) Railcar undercarriage and miscellaneous frame components are removed prior to burial.
- (2) All windows must be provided with closures, although ventilation may be expedited by modifying window space.
- (3) Access is proposed through existing doorways at end of car.
- (4) Entrance closures are required for radiation protection (Figs. A-16 to A-21)
- (5) Car interior to be upgraded with post and beam shoring (Fig. A-10)

## EXPEDIENT SHELTER FACT SHEET

### STORM DRAINAGE SYSTEMS

Major storm drainage facilities and their components can provide long-term shelter in host areas. Two components of a typical system are analyzed for shelter purposes:

- o Storm drain manholes
- o Major conduits -- 5 foot diameter and larger

#### **Limitations**

- (1) Manholes should be a minimum of 4 feet in diameter and 6 feet deep (see Figure A-4).
- (2) Manholes are often located in street traffic areas and therefore, may not always be available for shelters. Manholes located in street medians, parking, or non-traffic areas are more accessible.
- (3) Storm drainage conduits may have considerable depth of flow or be located in areas subject to tidal action, thus eliminating their availability.
- (4) Large closures may be necessary at conduit ends to eliminate blast effects. (Two psi won't endanger occupants directly, but can shatter glass). These closures should be measured, and all material prefabricated prior to the crisis period in order to install them within the 72-hour time frame (see Figure A-5).
- (5) Blast effects must be eliminated at all open drain inlets adjacent to the shelter locations. This can be accomplished by sandbagging.
- (6) Depth of water flow may necessitate construction of false floor systems. (See sketch of box culvert type of floor system in Fig. A-6.)

## **Advantages of Using Storm Drain System Components as Expedient Shelters**

### **Manholes:**

- (1) Storm drain manholes are numerous. On any major drainage system they are located from 500 to 1,000 feet apart.
- (2) They require no internal upgrading and are easily adapted to use as one-man shelters, with construction of a temporary wood floor and modifications to manhole lid and closures (see Figure A-4).
- (3) Ventilation equipment is not required, since air movement occurs through drain pipes at base of manhole.
- (4) Manholes as shown in Figure A-4 allow easy access to the major storm drainage system, and thus require less effort to provide entry systems than other expedient shelter types.

### **Drainage Conduit Systems Greater than 5 feet in Diameter:**

- (1) Radiation or fallout shielding is generally not necessary because of depth of burial.
- (2) Ventilation equipment is not needed, as the drainage systems provide natural ventilation at all inlet and outlet locations. Fabrication of radiation and blast resistant closures at inlets and blast resistant closures at outlets must be implemented.
- (3) Drain systems are often long enough to provide shelter for more than one industry.

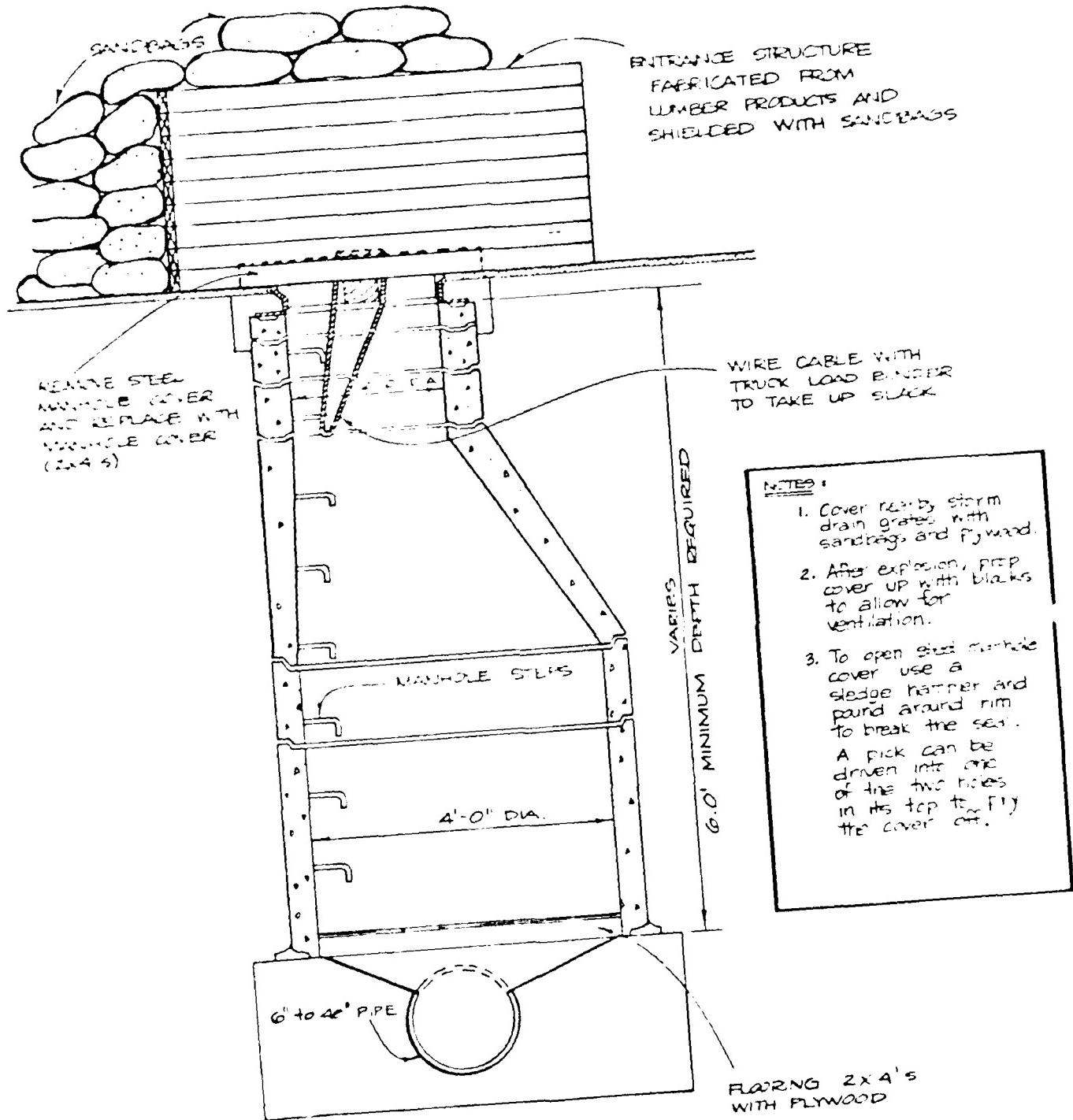


FIG. A-4. Host Area Shelter in Storm Manhole.

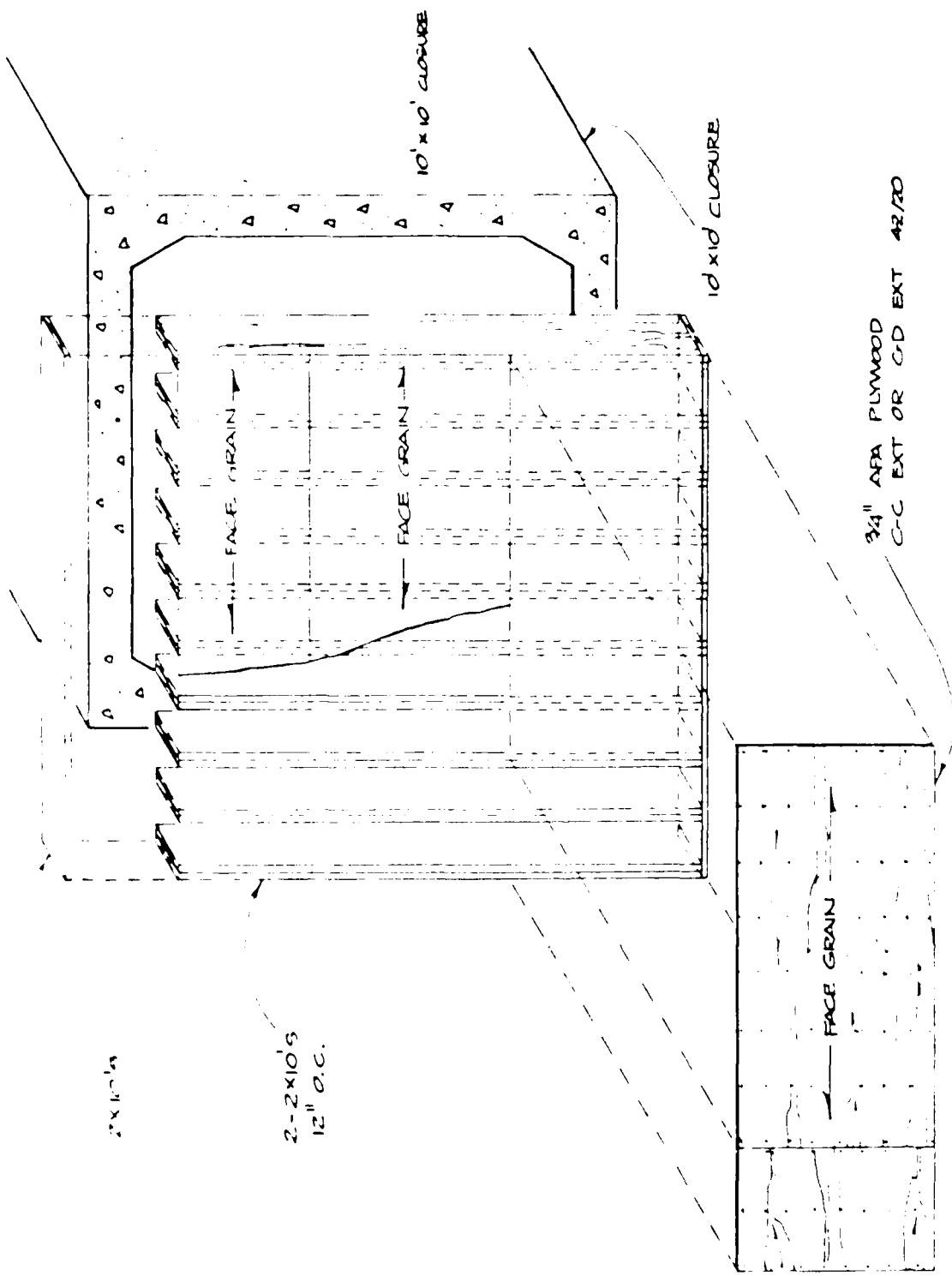


FIG. A-1. Typical closure for a 10 ft by 10 ft Box Culvert for 2 psf Blast overpressure.

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INDUSTRIAL PROTECTION MANUAL.(U)

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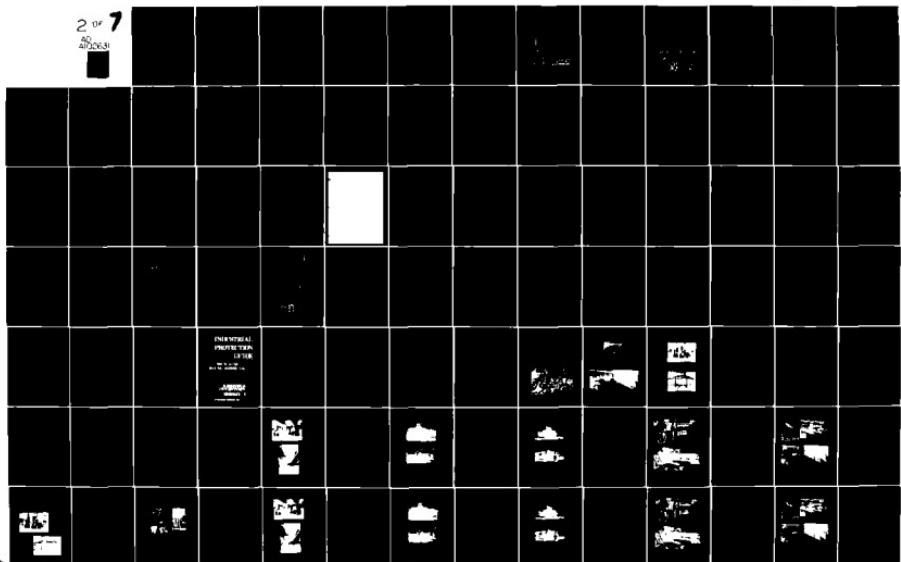
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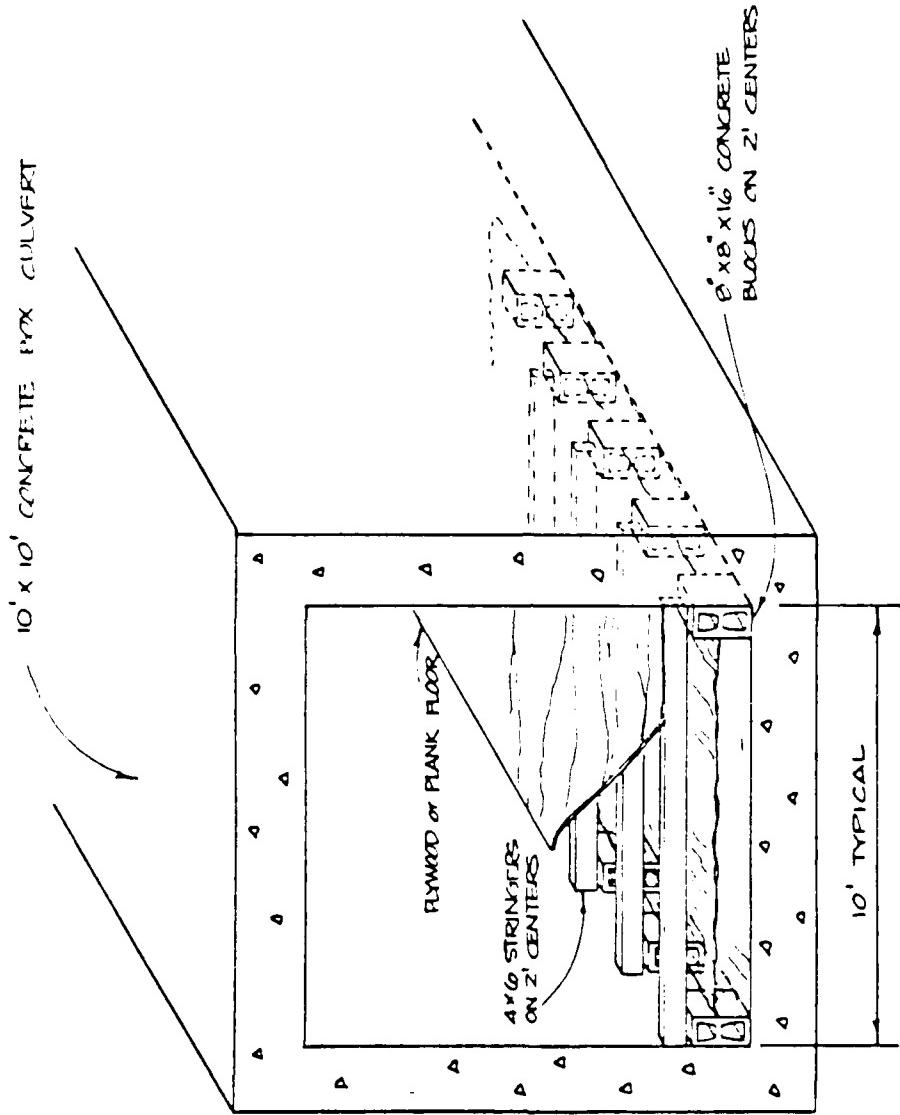
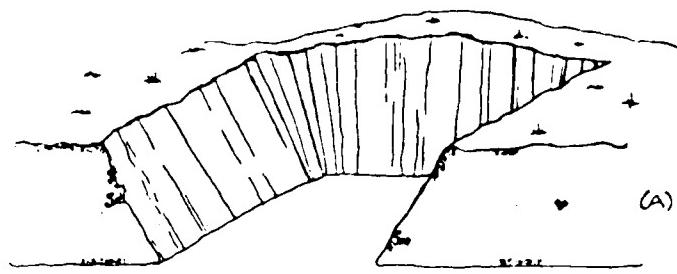


Fig. A-6. Box Culvert Host Area Shelter With Low-Flow False Floor.

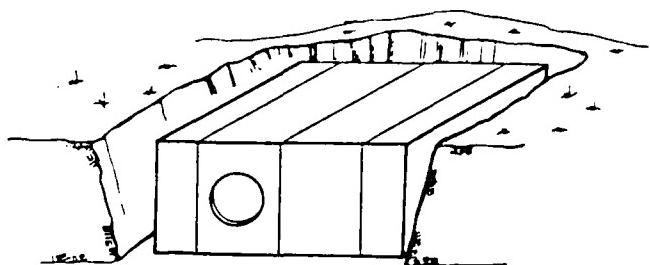
## EXPEDIENT SHELTER FACT SHEET CONCRETE UTILITY VAULTS

Adapting prefabricated underground utility vaults (the types used by telephone and electrical utilities) for Host Area shelters is recommended as a practical and easily implemented shelter option. The use of precast utility vault components for a shelter has been previously tested, and placement of a six-man vault and entrance structure, including earth cover radiation protection, required less than 10 hours using three men and heavy equipment.

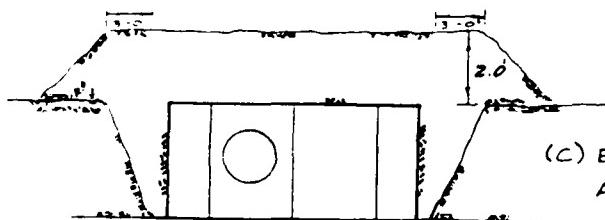
Figures A-7 and A-8 show the burial of a utility vault shelter consisting of various components needed to complete a shelter structure.



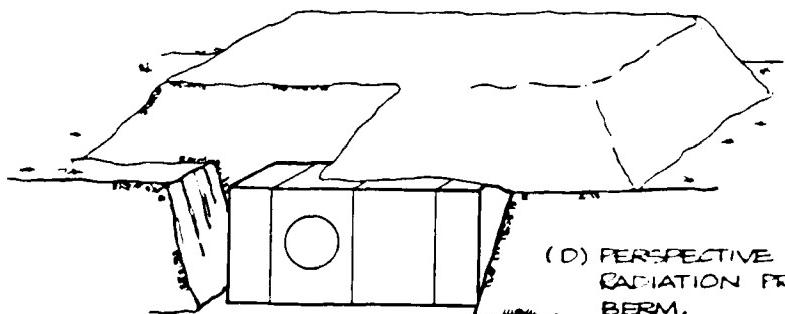
(A) EXCAVATION FOR UTILITY VAULT.



(B) VAULT IN PLACE PRIOR TO BACKFILLING.



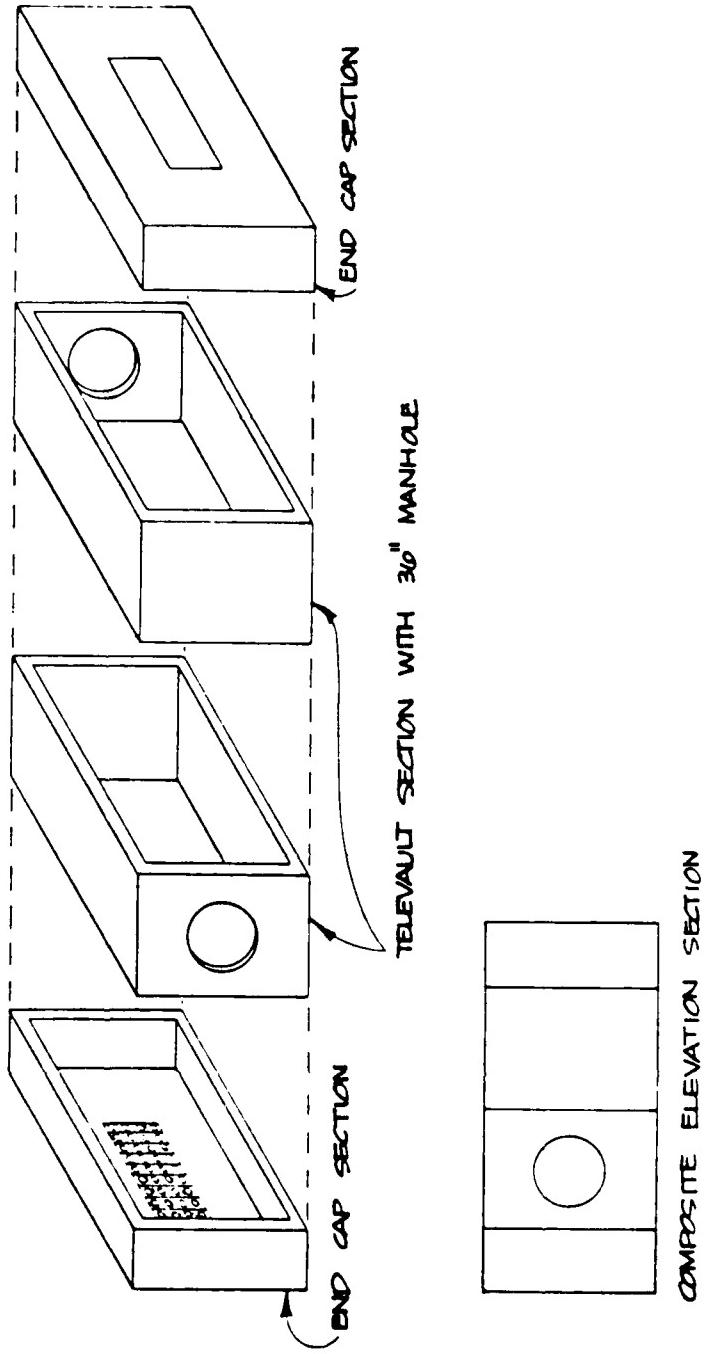
(C) END VIEW SHOWING BACKFILL AND RADIATION PROTECTION BERM.



(D) PERSPECTIVE VIEW OF RADIATION PROTECTION BERM.

Fig. A-7. Utility Vault Shelter.

ASSEMBLY DRAWING



A-19

Fig. A-8. Utility Vault Shelter Components, Depicting Upgrading Methods to Provide 2 psi Overpressure Protection.

## EXPEDIENT SHELTER FACT SHEET

### SHIPPING CONTAINERS

Maritime shipping containers are an easily adapted option to Host Area shelter use. A wide range of container sizes and construction types are available.

#### **Advantages of Using Maritime Shipping Containers for Shelter Purposes**

- o A wide variety of standard sizes are available:

Height	Width	Length
8'	8'	20'
8'	8'	40'
8'	8'6"	35'
8'	8'6"	40'

- o Construction materials are steel, stainless steel, glass fiber reinforced plywood (FRP), and aluminum. Nearly all are painted. Containers are generally designed for dry freight and some are insulated. Refrigerator units amount to approximately 7% of the total number manufactured. Typical containers are shown in Figure A-9.
- o The maritime industry has standardized construction details and lifting methods. Certification is required prior to approval for use. Component strengths are listed below.

Container Component	Design Strength, psi
Roof	0.5 +
Floor	26.0 ±
Endwall	1.7 ±
Sidewall	0.9 ±

These strengths reflect only the component listed. Frame members are designed to be stacked fully loaded, nine containers high. The

frame members provide all exterior lifting strength, and thus would provide additional strength.

- o The majority of containers are designed to be waterproof.
- o Upgrading to 2 psi overpressure and radiation protection of 2 feet or more of earth can be provided with post and beam shoring (see Figure A-10). After nuclear blast effects are no longer a threat, the intermediate post shores may be removed.
- o Containers are readily available from manufacturers, repair companies, and firms that deal exclusively in surplus containers.
- o Containers are designed to be adapted to a variety of cargo handling and lift equipment. Empty 20-foot containers weigh approximately 4,300 lb, 40-foot containers, 7,500 lb. (Figures A-11 and A-12).
- o Prior to the crises envisioned in a nuclear war, the containers may be used for secure locked storage of shelter resources and supplies.
- o Containers are easily transported to the site by truck and trailer.

**Limitations:**

- o The containers are available at nearly every major port facility, but not nationwide.
- o Demand for used containers is high, because of their storage capabilities and versatility.

Maritime shipping containers when properly implemented could be a valuable option to provide shelter. The inherent structural strength of the floor systems indicate containers may possibly survive blast pressures in excess of 20 psi if buried upside down with proper shoring. Full-scale field tests are recommended to determine ultimate capability.

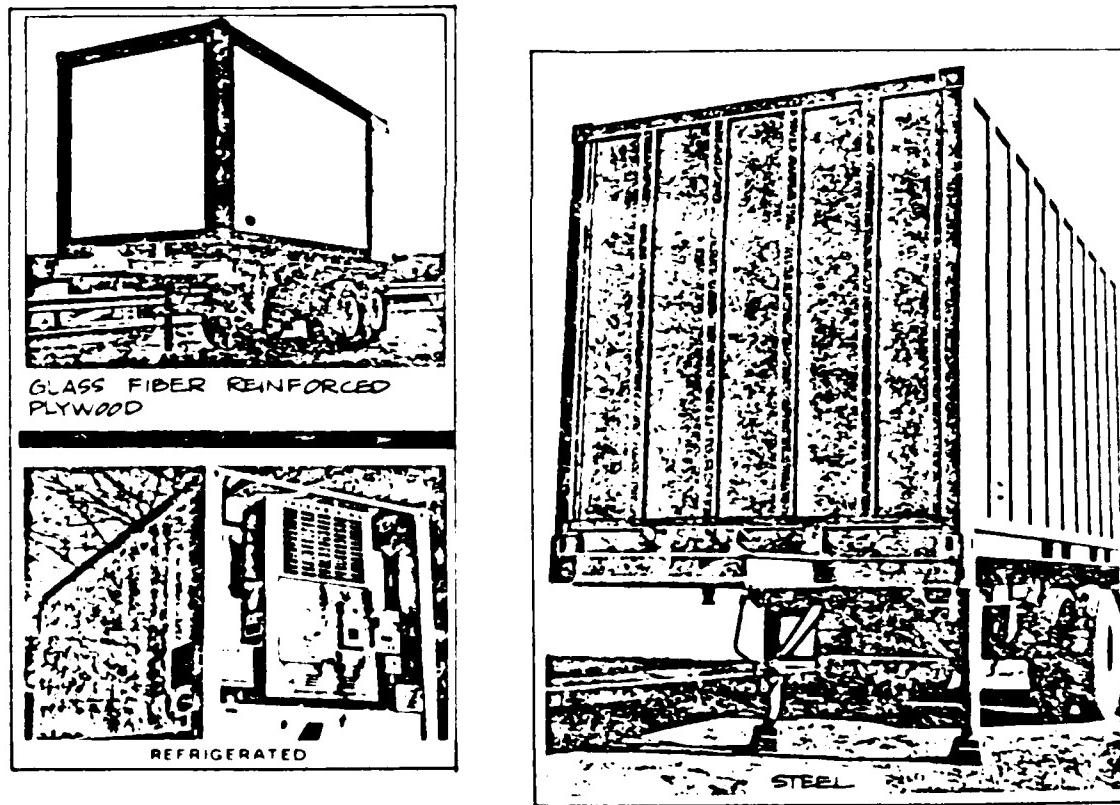
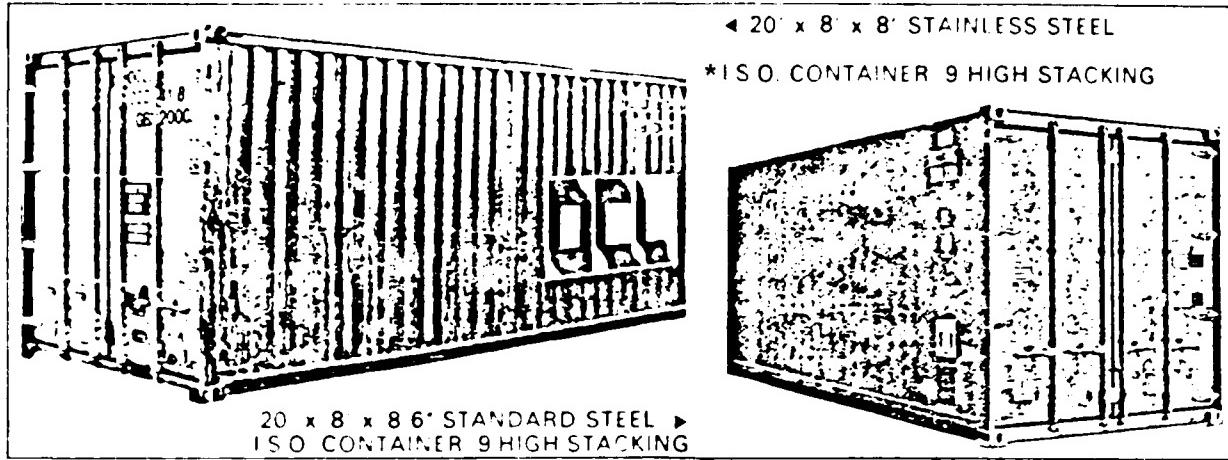


Fig. A-9. Typical Maritime Shipping Containers.

\* International Standards Organization.

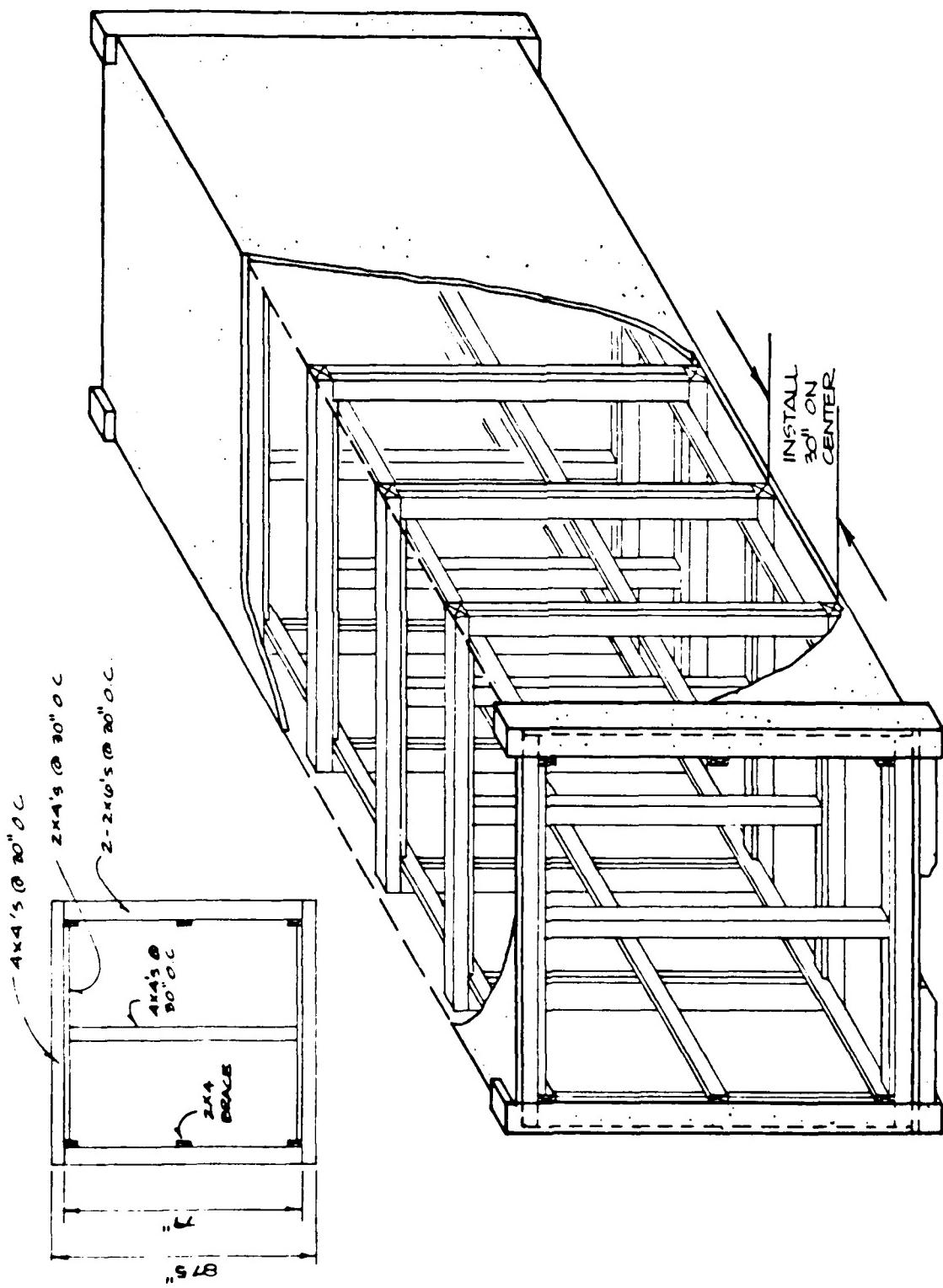


Fig. A-10. Post and Beam Shoring of Maritime Shipping Containers, Railcars, and Truck Van Bodies.

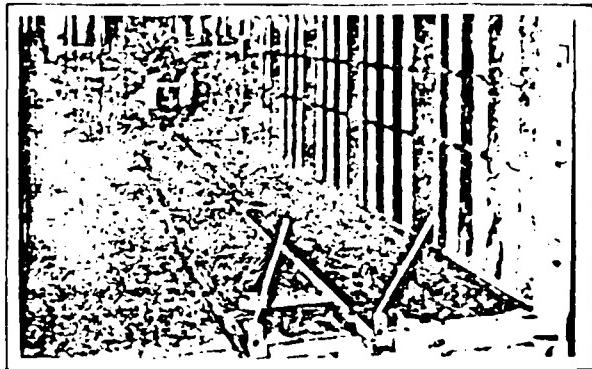


Fig. A-11. Typical Interior Details.

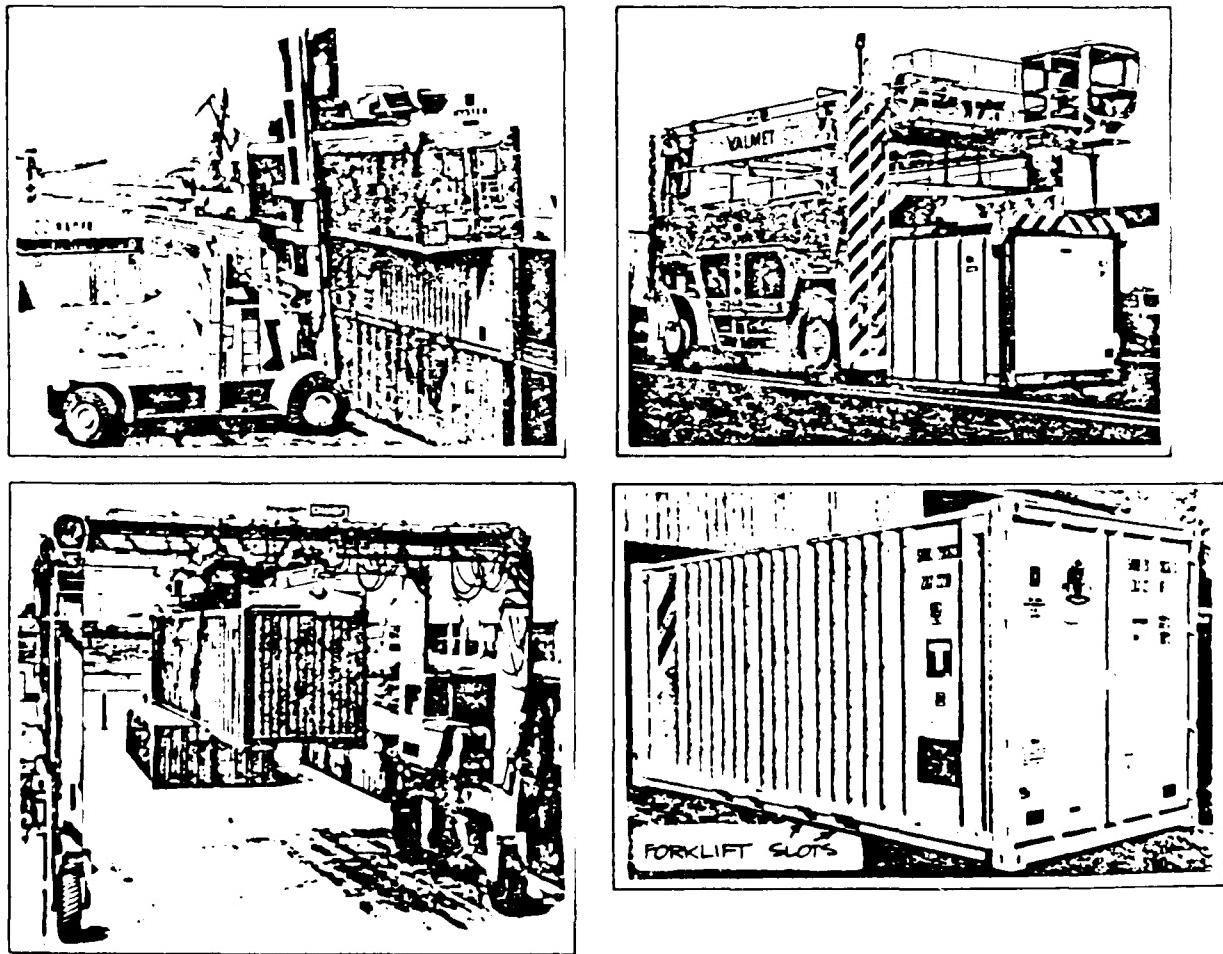


Fig. A-12. Typical Lifting Methods.

## EXPEDIENT SHELTER FACT SHEET

### TRUCK VAN BODIES

Another resource option for Host Area shelters are truck van bodies (see Figure A-13). Construction types and design capabilities are similar to maritime shipping containers.

#### **Advantages of Using Truck Van Bodies for Host Area Shelter Purposes:**

- o A wide variety of sizes are available. They are designed for a variety of uses.
- o Construction materials are steel, stainless steel, and aluminum.
- o They are waterproof.
- o With post and beam construction (Figure A-10), these units can be upgraded to 2 psi overpressure and provided with earth cover radiation protection.
- o They are readily available throughout the United States.
- o They are integral with trailer frame and chassis, ready to be moved.
- o They may be used for secure locked storage for shelter supplies and resources.

#### **Limitations to Truck Van Bodies as Host Area Shelters:**

- o They are constructed integral with trailer frame and wheels, and thus reduce the inventory of available transportation resources in the crisis period.
- o Without the trailer frame, structural integrity is eliminated. Thus, they would require significant effort and resources to re-establish equivalent capability as a shelter option.
- o Demand for trailer van bodies is high, and they consequently would be a more costly alternative to other options.

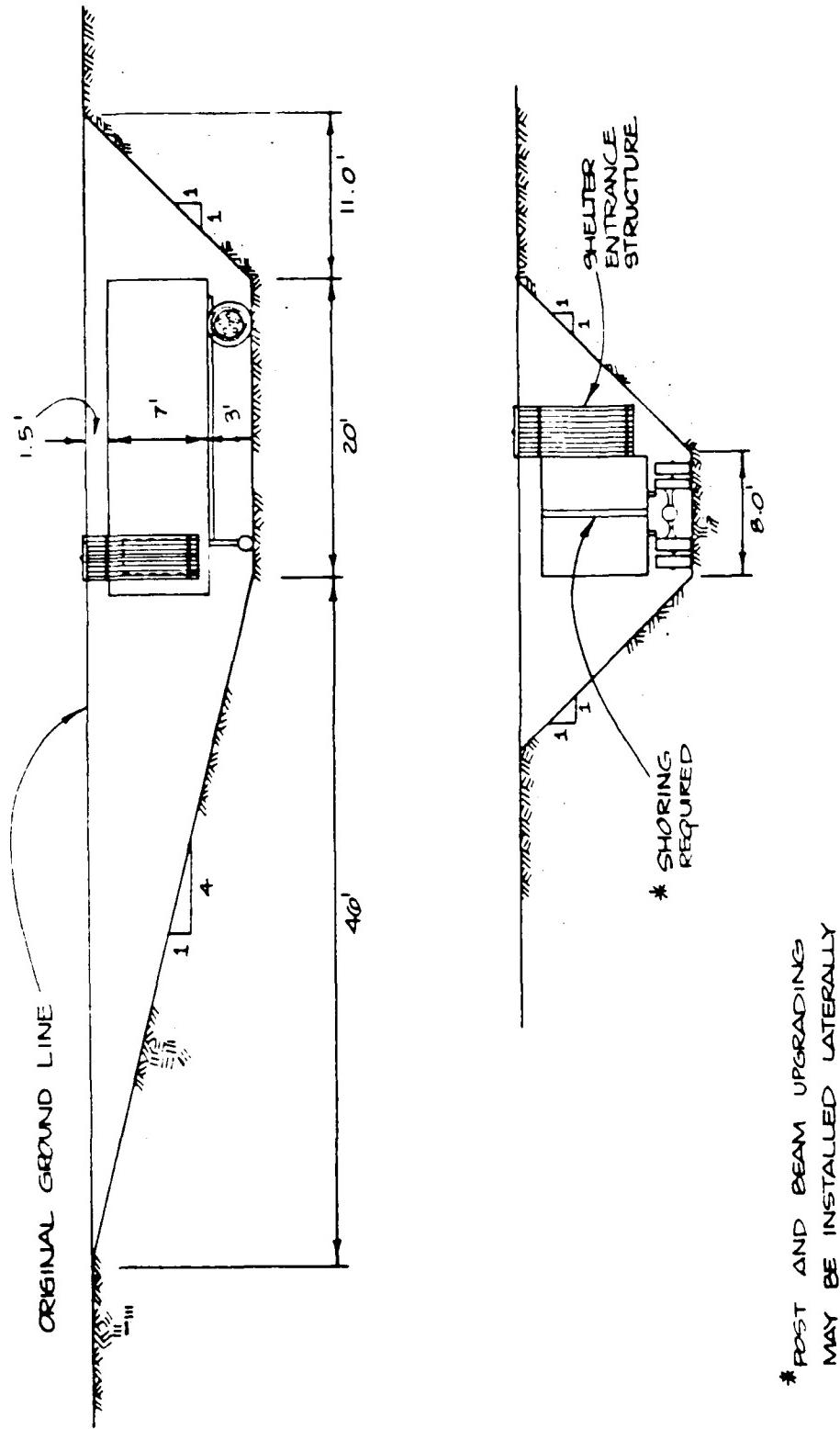


Fig. A-13. Buried Truck Trailer Van, Host Area Shelter.

TABLE A-4: EXPEDIENT HOST AREA SHELTER PREPARATION TIME

EXPEDIENT SHELTER OPTION	UNDERGROUND BURIAL	ACCESS/VENTILATION FLOOR CONSTRUCTION	SHELTER SUPPLIES
<b>RAILROAD CARS</b>			
REFRIGERATOR	3 MEN, 16 HRS	3 MEN, 24 HRS	2 MEN, 10 HRS
BOX CARS	3 MEN, 16 HRS	3 MEN, 30 HRS	2 MEN, 10 HRS
CABOOSE	3 MEN, 12 HRS + (UPGRADING) 2 MEN, 20 HRS	3 MEN, 20 HRS	2 MEN, 10 HRS
PASSENGER CARS	4 MEN, 20 HRS + (UPGRADING) 3 MEN, 8 HRS	3 MEN, 30 HRS	3 MEN, 10 HRS
<b>STORM DRAINAGE FACILITIES</b>			
MANHOLES	N/A	1 MAN, 8 HRS	1 MAN, 8 HRS
LARGE PIPES	(CLOSURES) 4 MEN, 20 HRS	4 MEN, 24 HRS	2 MEN, 10 HRS
BOX CULVERTS	(CLOSURES) 4 MEN, 30 HRS	4 MEN, 30 HRS	2 MEN, 10 HRS
MARITIME SHIPPING CONTAINERS	3 MEN, 12 HRS + (UPGRADING) 2 MEN, 8 HRS	3 MEN, 20 HRS	2 MEN, 10 HRS
CONCPETE UTILITY VAULTS	3 MEN, 10 HRS	3 MEN 10 HRS	2 MEN, 10 HRS
TRAILER TRUCK VAN BODIES	3 MEN, 10 HRS + (UPGRADING) 2 MEN, 8 HRS	3 MEN, 10 HRS	2 MEN, 10 HRS

## EXPEDIENT SHELTER FACT SHEET

### OTHER OPTIONS

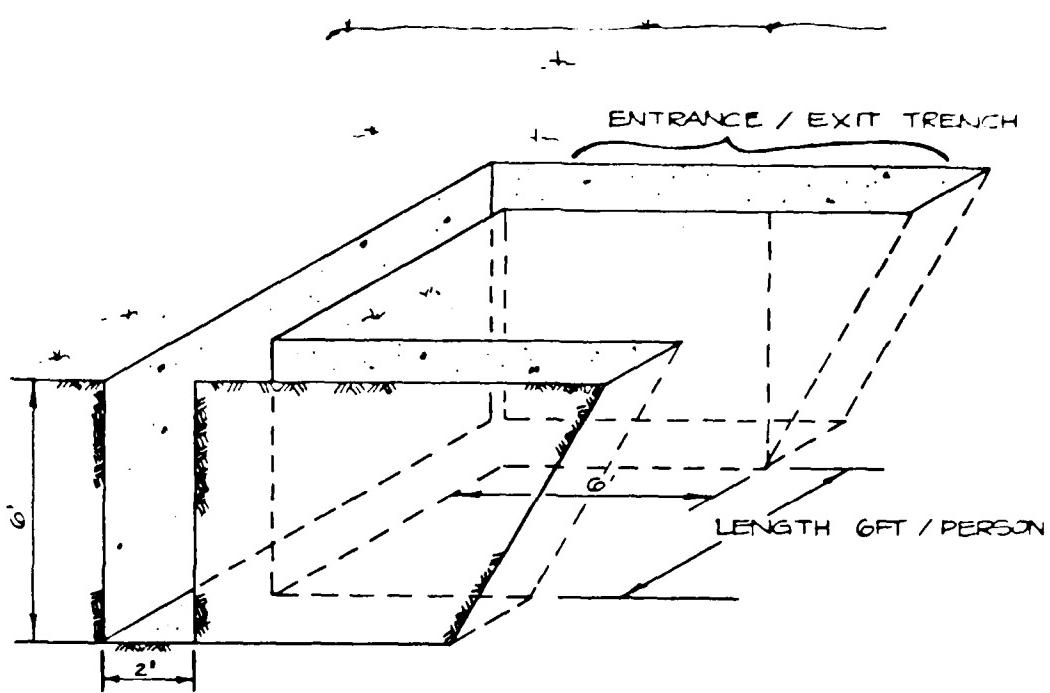
There are a number of other options to provide Host Area shelters. These options may not be the most desirable for long stay-times, but they do provide adequate radiation protection.

#### **Trench Shelters**

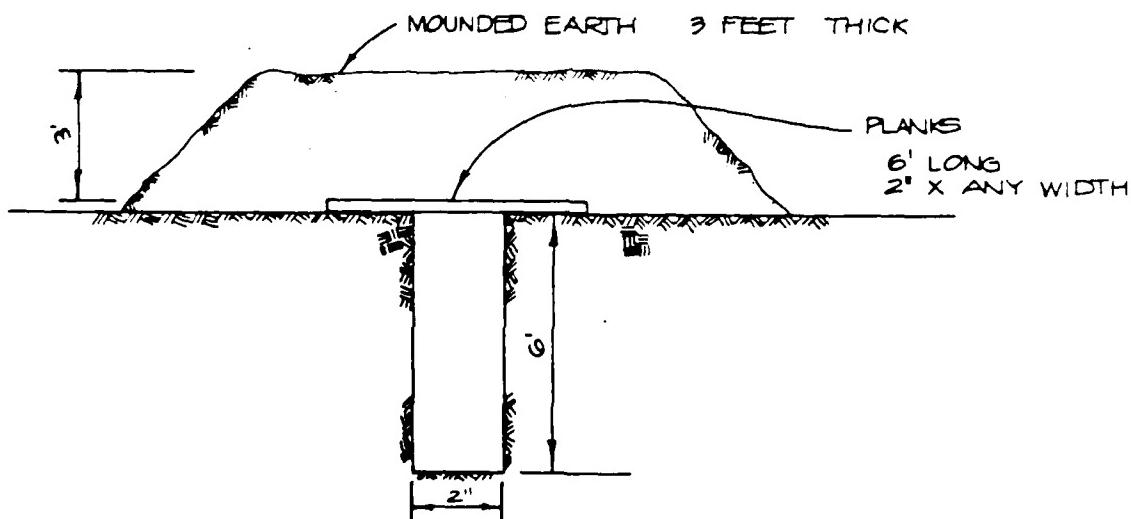
Figure A-14 describes a typical trench shelter. Implementation requires only mechanical excavation equipment, sufficient planks or other resources for support of the mounded earth, and soil strata that will stand vertical to a depth of 6 feet with no ground water at that excavation depth.

#### **Fabricated Manholes**

Figure A-15 describes in some detail a shelter fabricated from readily available reinforced concrete and corrugated metal pipe. The construction of such a shelter requires only a backhoe for excavation and backfill. The expedient manhole cover should have an entrance structure similar to the one shown in Figure A-16 including sandbag radiation protection.



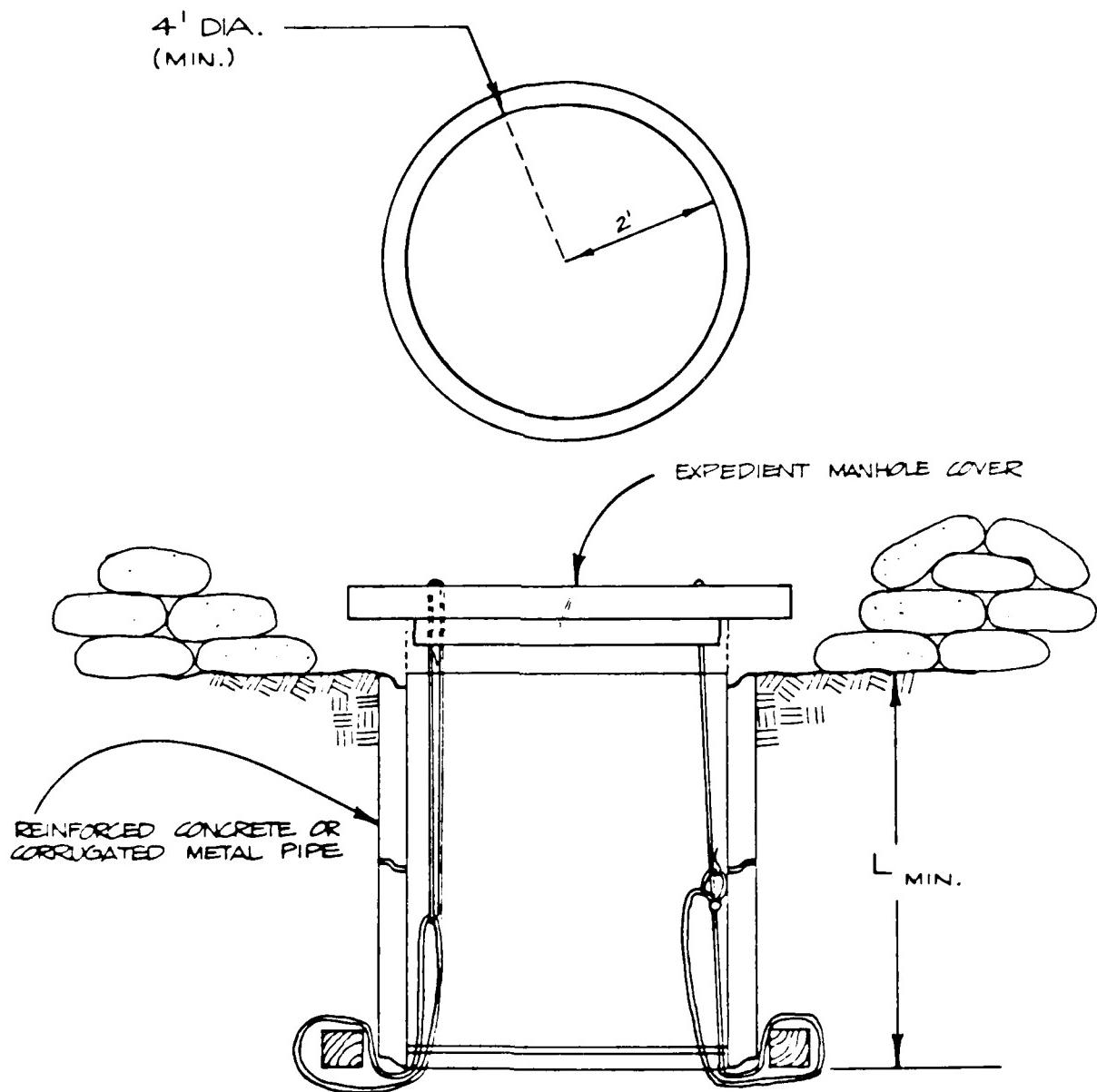
TRENCH SHELTER PRIOR TO PLACING PLANKS AND MOUNDED EARTH



SIZE TRENCH FOR NO. OF PEOPLE - 6 LIN. FEET / PERSON

- NOTES:
1. Place planks.
  2. Place newspaper, plastic sheets, etc. to keep dirt from falling through cracks.
  3. Place 3 ft. of dirt over planks.

Fig. A-14. Expedient Host Area Trench Shelter.



4' DIA. - 1 MAN SHELTER ( $L_{MIN} = 6'-0''$ )

5' DIA. - 2 MAN SHELTER ( $L_{MIN} = 7'-0''$ )

6' DIA. - 3 MAN SHELTER ( $L_{MIN} = 7'-0''$ )

7' DIA. - 4 MAN SHELTER ( $L_{MIN} = 7'-0''$ )

8' DIA. - 5 MAN SHELTER ( $L_{MIN} = 6'-6''$ )

Fig. A-15. Fabricated Manhole-Like Shelter.

## **CLOSURE AND ENTRY ALTERNATIVES FOR UNDERGROUND SHELTERS**

The development of 2 psi blast resistant and radiation protected Host Area shelter space requires that consideration be given to shelter entry structures. In cases where existing basement areas are to be upgraded, shelter entry is not a significant problem; instead, providing closures for existing openings must be considered. A radiation protected entrance to all below ground entries is shown as Figure A-16.

### **Shelter Entry Structures**

Expedient shelters require fabrication of novel entry structures including efficient use of available resources. A typical wood construction vertical entry structure is shown in Figure A-17 and suitable closure is shown in Figure A-18.

As an alternative to wood construction, concrete pipe or corrugated metal pipe entry structures may be used. Figure A-19 shows such a structure, and Figure A-20 is a suitable closure for a circular entry structure.

A combination wood construction drop entry and pipe construction horizontal entry structure is shown as Figure A-21. This figure provides details using alternative combinations of available materials.

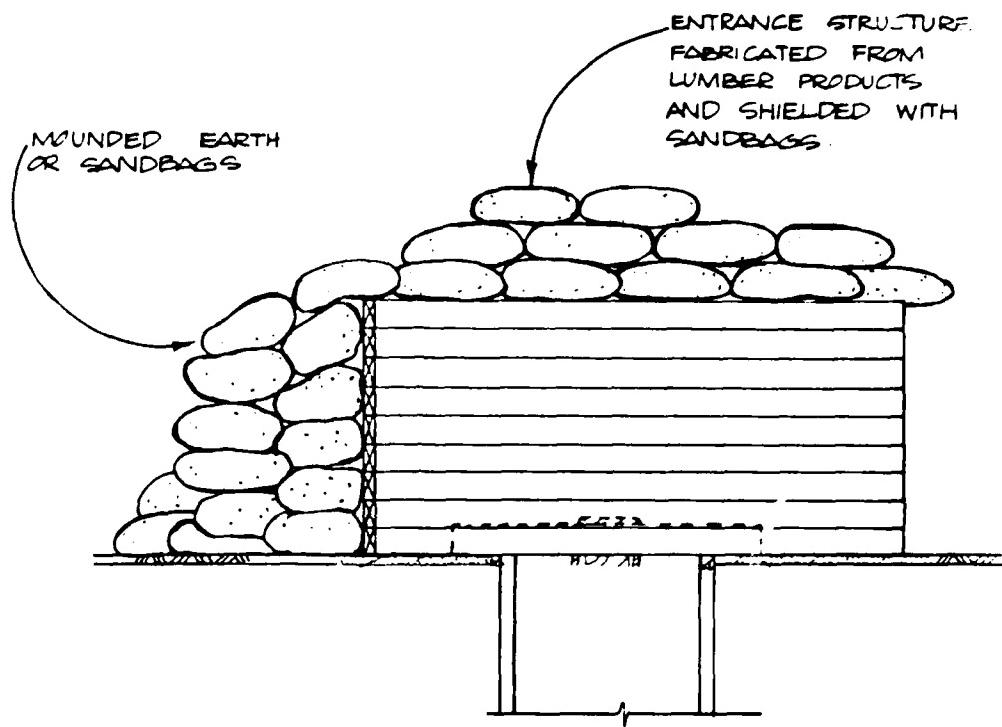


Fig. A-16. Radiation Protected Entrance Structure to All Below Ground Shelters.

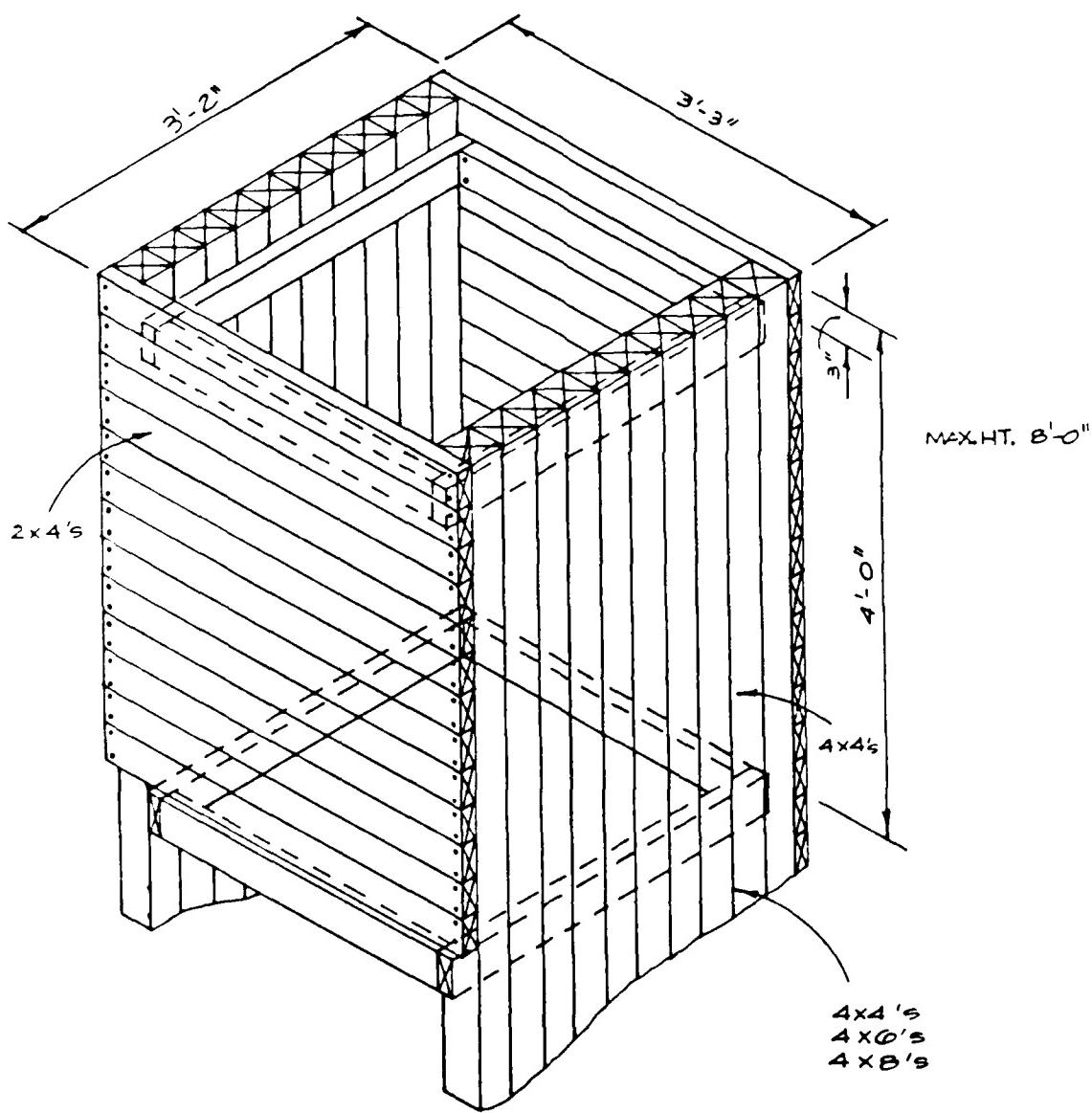


Fig. A-17. Host Area Shelter Entrance.

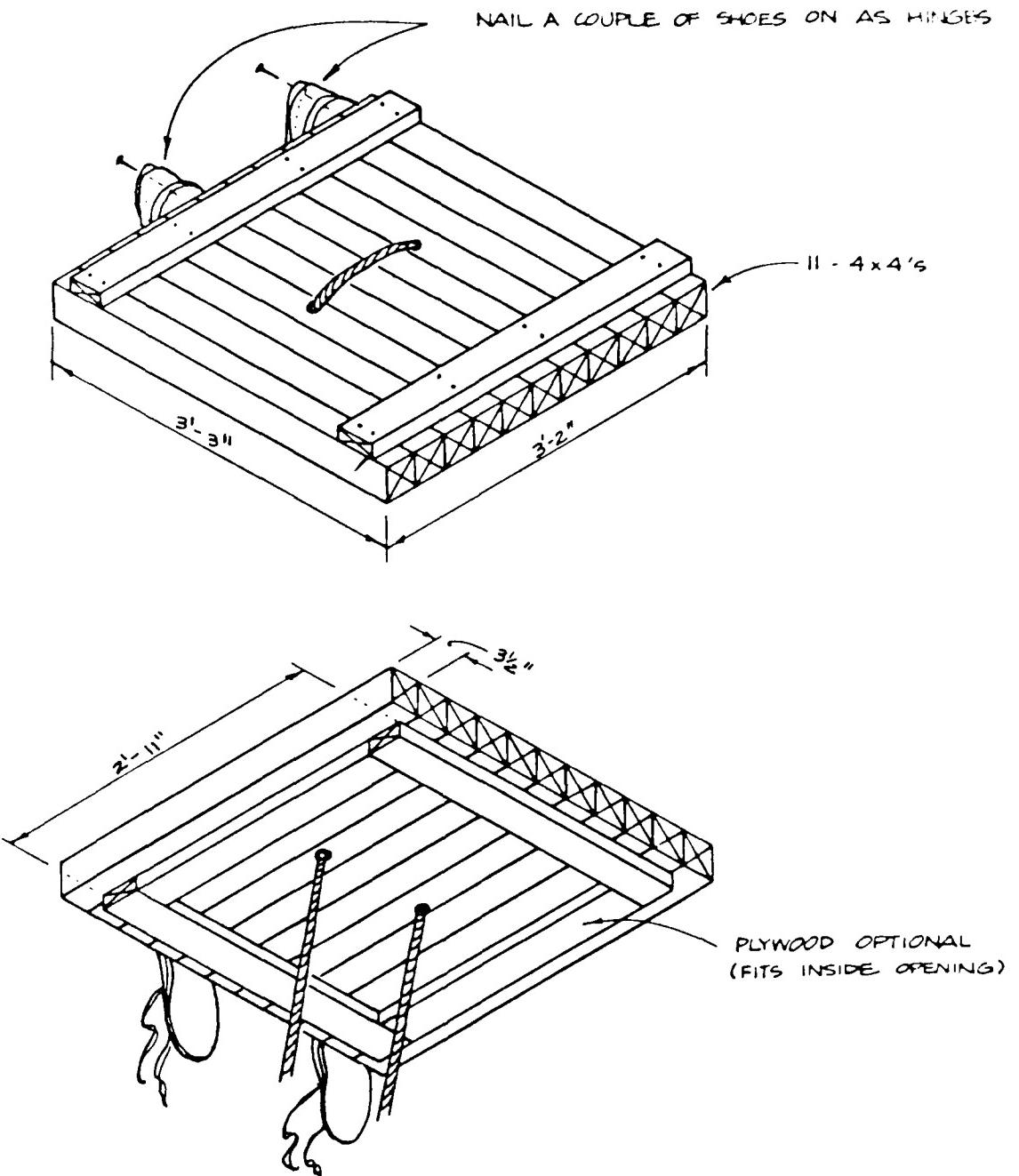


Fig. A-18. Host Area Shelter Door.

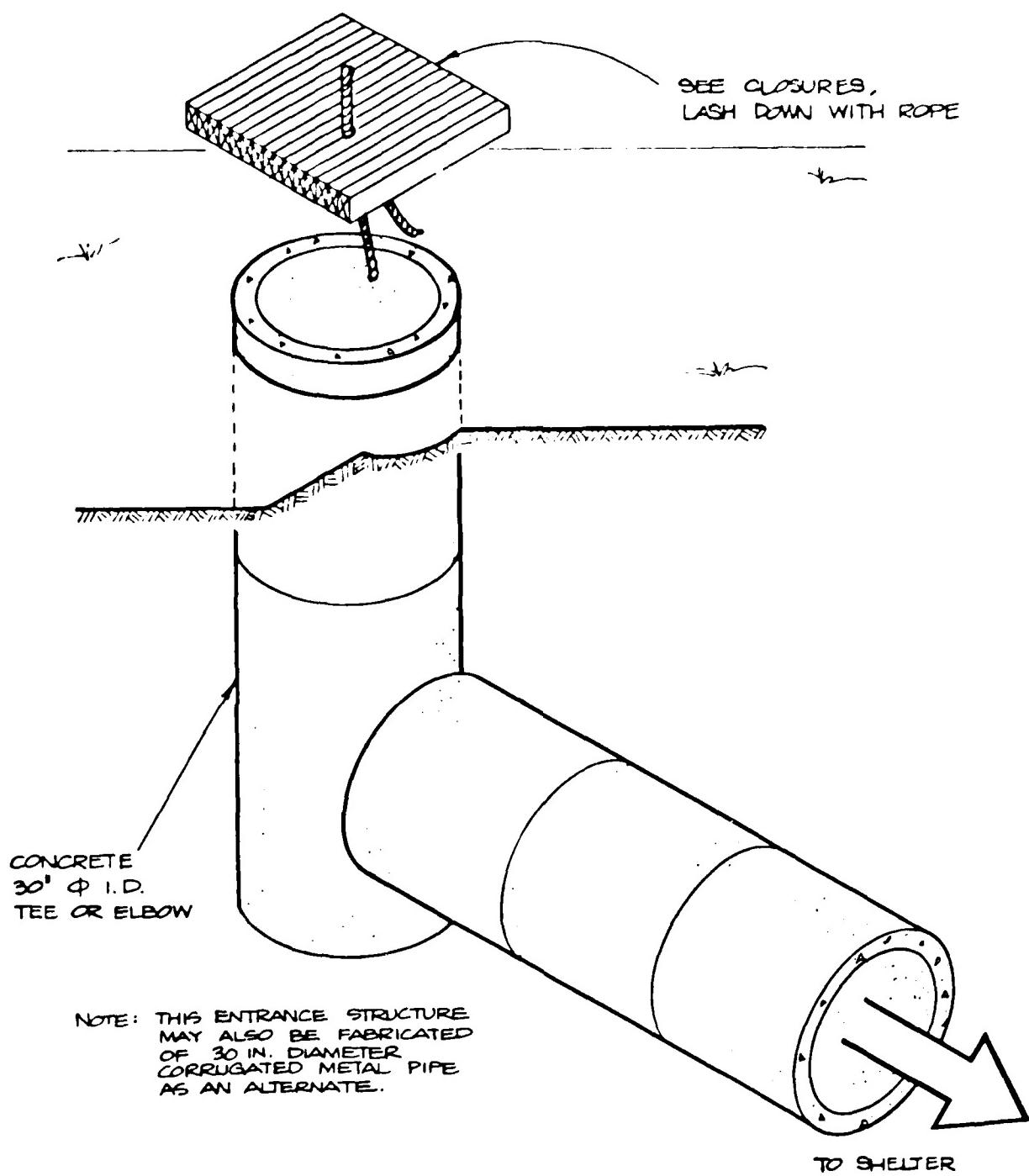


Fig. A-19. Entrance To Shelter.

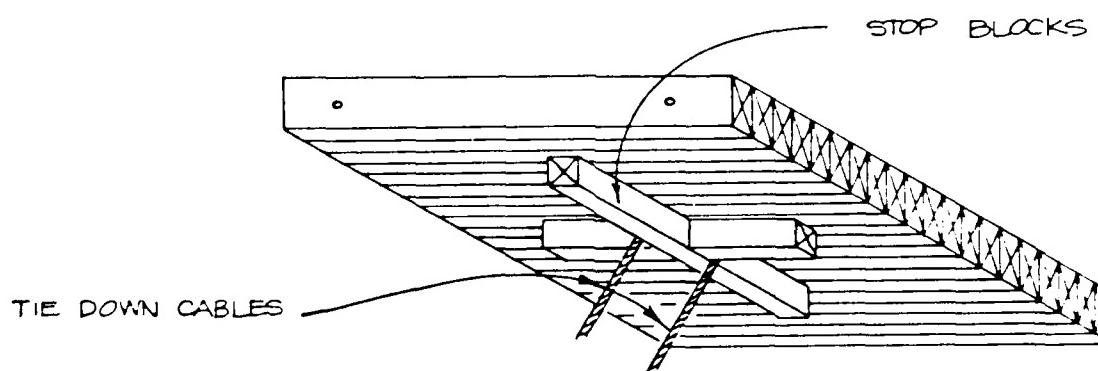
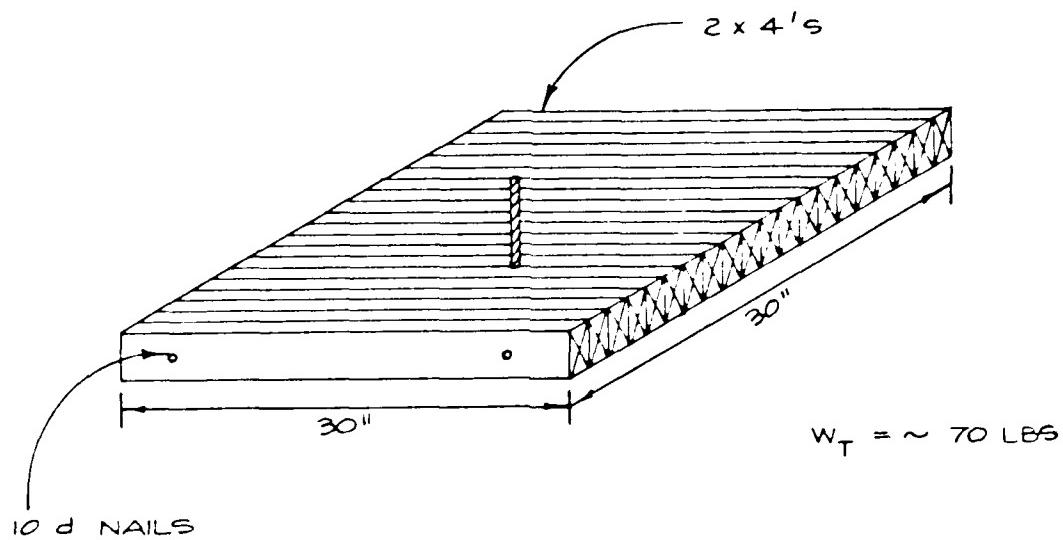
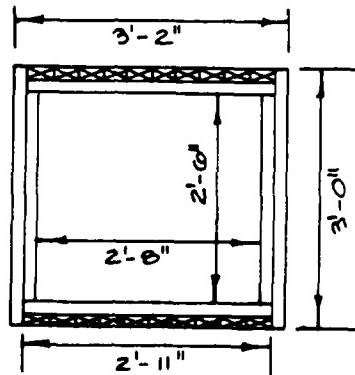
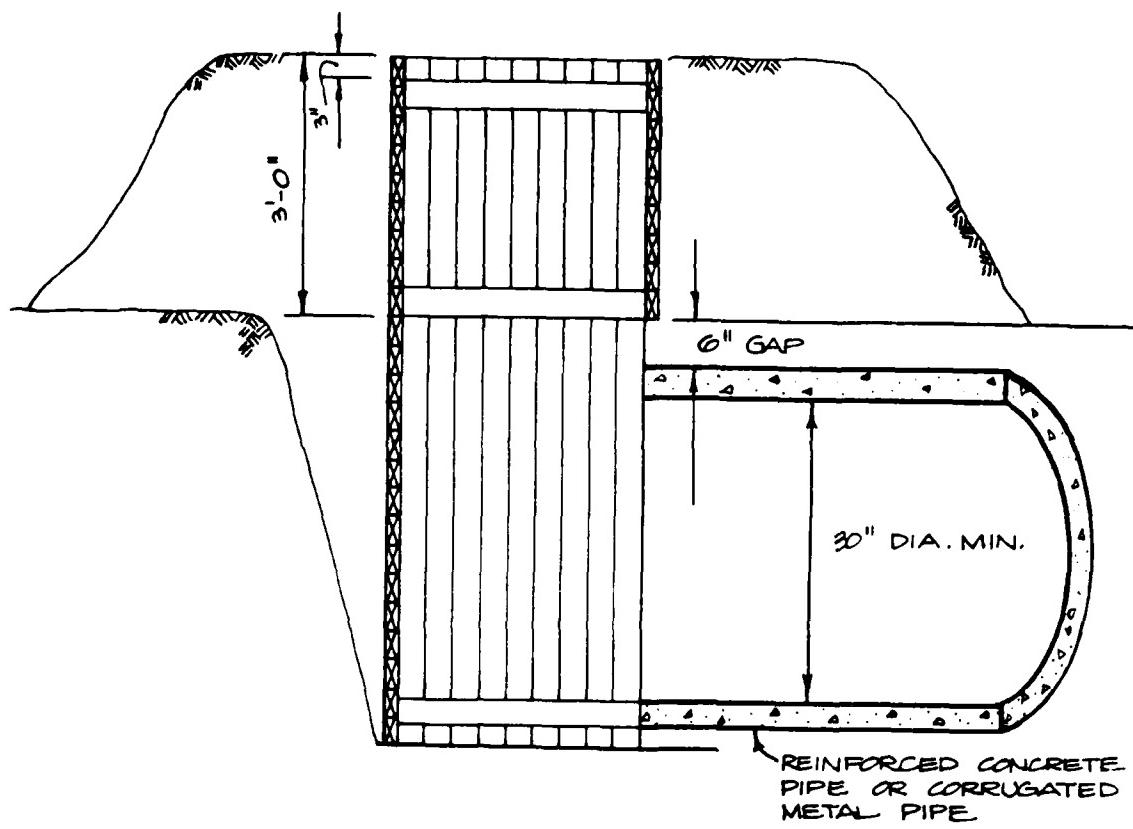


Fig. A-20. Expedient Manhole Closure, Host Area.



**Fig. A-21. Typical Entryway to Buried Shelter With Culvert Shown.**

**APPENDIX B**

**SHELTER MANAGEMENT  
PERSONNEL RECOVERY  
BIBLIOGRAPHY**

## **SHELTER MANAGEMENT**

The civil defense preparedness effort is based on implementation of a national network of shelters, of which Host Area shelters are a major part.

Under nuclear attack crisis conditions, the responsibility of a shelter manager is significant. Access to outside support will be minimal and perhaps non-existent for some time. The sheltered employees and their families will be living under severely crowded conditions, movement will be limited, resources will be limited to supplies and equipment in the facility, and their anxiety levels will be high.

### **A Host Area shelter must be self-reliant**

A Host Area shelter may be closed off from the rest of the community for a period as long as 14 days. The supplies, services, and professional skills available will be contained within the facility and among the shelterees. Shelter life is a severe physical, mental, and emotional demand upon the manager's leadership; upon the staff he designates; and upon all members of the sheltered population.

Managing a Host Area shelter combines skills in operating a hotel, industrial plant, and leading people in an emergency. In addition, the shelter manager is responsible for ventilation, fire protection, and the following functions:

- Registration of occupants
- Assignment of space
- Rules and regulations of occupancy
- Selection and assignment of assistants (delegate authority as required)
- Security and safety of occupants
- Morale, including religious, psychological counseling, and recreation activities
- Obtaining and disseminating national and local information
- Attention to social service requirements
- Logistical requirements
- Assuring facilities for personal hygiene
- Maintaining adequate sanitation

Providing for the comfort of occupants  
Health services  
Security for valuable personal possessions  
Disposition of the dead  
Continued upgrading/improving shelter, and expedient shelter construction  
Radiological protection  
Atmosphere control

Host Area shelters are to be stocked with supplies and equipment (food and water, medical and sanitation kits, packed ventilation kits, radiation survey meters, dosimeters with which to measure doses of radiation). If the shelter is not stocked the manager must acquire needed materials.

Here are the most urgent requirements:

Water  
Food  
Emergency ventilation equipment  
Emergency lighting equipment  
Hand radios  
Shovels, hand tools, nails  
Basic medical supplies  
Sanitation equipment  
Administrative materials  
Recreational materials  
Essential toilet articles

The average living space per person will be only 10 square feet. Living conditions will be somewhat austere. Facilities and procedures for personal hygiene, sanitation, medical attention, and recreation will be severely limited.

## **The Host Area Shelter Manager**

As Host Area shelter manager you must give special attention to:

(1) **Radiological Defense.** People can protect themselves against fallout radiation, and have a good chance of surviving, by removing themselves as far as possible from the fallout particles outside. In addition to protecting people from fallout, most shelters would also provide some limited protection against the blast and heat effects of nuclear explosions that were not close by. Basement shelters better protect persons inside from absorbing many of the gamma rays given off by fallout particles outside.

(2) **Ventilation.** Shelter populations cannot survive without air. Atmosphere and temperature control are handled by methods of air exchange: introducing fresh air into the shelter and simultaneously removing stale air.

(3) **Communication.** It will be difficult to get information about the outside world. It is the manager's responsibility to see that someone monitors the Emergency Broadcast System on a battery-operated radio at all times. Once a shelter is closed, it is urgent to try to get information on what is happening and to relay it quickly to the population, to promote morale and cooperation, and to avoid rumors and their inherent dangers.

(4) **Morale.** In such a trying ordeal of confinement, maintaining morale is critical. All religious, psychological counseling, and recreational activities must be carried out within the group. The manager must remember the importance of a sense of humor as well as a calm confidence.

A Host Area shelter manager must be prepared to cope with every aspect of the lives of all sheltereeess on a 24-hour basis.

In a Host Area shelter, the community's established law enforcement procedures will be absent. Further, if there are law enforcement officials present in the shelter, they will still be reporting to the Manager. Therefore, the

Manager is ultimately responsible for maintaining order, and for encouraging and enforcing our society's standards of moral and humane behavior.

The fallout shelter manager functions as an extension of local government within the shelter, supervising shelter operations until organized units of government can resume direction of the community recovery effort. The manager is there to maintain life and return to the post-attack world shelterees who are physically and psychologically able to help in the recovery effort.

Rapid decisions, visible leadership, demonstration of and delegation of authority are vital. The efficiency of shelter operation will ultimately depend on the shelter staff selected by the shelter manager. It is expected that some industry shelters will have in excess of 100 shelterees. Successful management of these numbers of people will be based on how good a staff is selected. The following guidelines are listed for shelter staff selection:

- (1) Choose core management staff
- (2) Choose and instruct team leaders for protective functions
  - a) Fire safety and security
  - b) Communications
  - c) Health and sanitation
  - d) Food and water
  - e) Maintenance and supplies
- (3) Choose a team leader for registration, identification, and assignment of space
- (4) Choose staff or task teams to be responsible for:
  - o Radiological defense
  - o Supply
  - o Technical operations, repair and maintenance
  - o Medical
  - o Fire
  - o Safety and rescue
  - o Communications
  - o Administration

- o Water
- o Food
- o Sanitation
- o Security
- o Night watch
- o Psychological first aid
- o Training and education
- o Support and special services
- o Exercise, recreation, and religion

(5) Staff selections are needed for:

- o Organizing the shelter population into community groupings
- o Developing a floor plan for major functions and areas
- o Appointing an advisory committee as liaison between sheltrees and manager

#### PERSONNEL RECOVERY

After a nuclear weapons explosion, industry workers will have approximately one-half hour to find shelter before fallout begins to deposit. Further away, fallout might not begin for an hour or two after the explosion. With preplanning and preparation, most industry workers can use this time to evacuate to the Host Area or to some other prepared shelter location with more supplies and space; however, roads and highways may be covered with litter, and thus impassable by car.

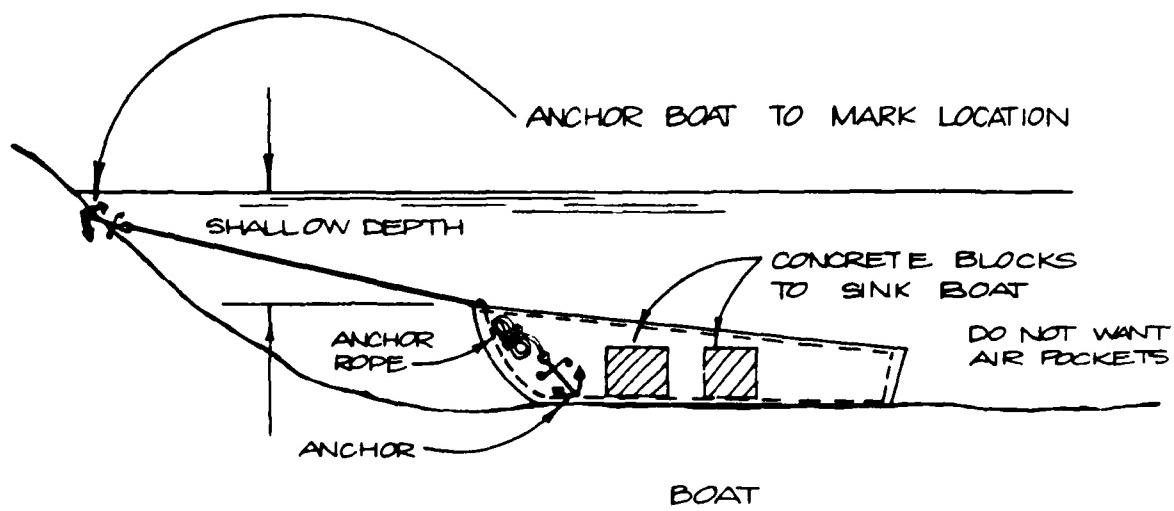
On foot, a man can travel two or three miles in half an hour, but if a bicycle, motorcycle, or four-wheel-drive off-highway vehicle is stored near the industry, the distance traveled after a nuclear burst but prior to the arrival of fallout may be greatly increased. This is somewhat dependent on damage along the route.

In industrial areas there is also a likelihood of numerous secondary fires caused by nuclear weapon damage. These fires could cause an additional latent

hazard to people sheltered in the risk area. Finally, if the explosion occurs during a personnel shift change, overcrowding of the industry shelter is another possibility that would make escape from the risk area desirable. If suitable escape vehicles and routes are provided, key worker personnel will have the flexibility of relocating to the Host Area to take shelter where hazards are generally less. An alternative that may be much preferred over wheeled vehicles for transporting key workers out of the risk area in an emergency is by waterways -- if they are within a mile or two. Waterways are less likely to be blocked or impassable. Figure B-1 shows a method to protect boats from blast damage.

To ensure recovery of personnel from the risk area after the nuclear attack, consideration must be given in advance -- and Host Area support provided. The following criteria should be used to provide for such recovery:

- (1) Plan mutual support between or among shellees in the risk area to get out of blast shelters and to get where Host Area rescue teams can make pickup.
- (2) Locate the buried shelters accurately with respect to some reference that will be easily identifiable after the attack. Debris from other areas may obscure or cover the shelter entrance.
- (3) Strategic location of individual transportation -- motorcycles or other vehicles as discussed earlier, or if near a large body of water, boats (Figure B-1). These should be left in the risk area. Larger transportation vehicles should be made ready in the Host Area for rescue with a few individual scout vehicles to assess access routes.



STORE IN SHELTER:

1. BAILING BUCKETS AND SPONGES FOR WASH DOWN
2. LIFE JACKETS
3. OARS AND MOTOR (STORE GAS OUTSIDE SHELTER IN HARDENED HOLE)
4. TARP BOAT COVER

SINK BOAT IN CHEST DEEP WATER SO THAT CONCRETE BLOCKS CAN BE TAKEN OUT AND BOAT REFLOATED.

Fig. B-1. Preparation and Protection of Boat for Escape Vehicle.

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**CRISIS RELOCATION INDUSTRIAL HARDENING PLAN**

**Booklet 4**

**PROTECTIVE HOUSEKEEPING**

This is one of ten booklets of the Industrial Hardening Manual  
developed for the  
**Federal Emergency Management Agency**  
under Contract No. EMW-C-0154, Work Unit 1124E

**SCIENTIFIC SERVICE, Inc.**  
Redwood City, California 94063

Booklet 4  
**PROTECTIVE HOUSEKEEPING**

**Coordinator:** \_\_\_\_\_

(name)

**Alternate:** \_\_\_\_\_

(name)

**Objective:** To reduce the hazards caused by secondary effects of disasters by taking action to prevent or reduce the number of opportunities for secondary effects to happen.

This booklet is part of a plan to protect industrial plant equipment from possible damage in event of a major disaster. It develops an approach for implementing protective housekeeping that can reduce the severity of earthquake, hurricane, tornado, and weapons effect damage to equipment left onsite. Fires are a major destructive force in such large-scale disasters, so onsite combustible materials must be removed or neutralized. To reduce hazards from toxic and hazardous materials during recovery, containers must be protected from rupture or puncture. To reduce damage from electromagnetic pulses, all electrical systems not deliberately functioning must be unplugged from power lines, and antennas disconnected. To reduce puncture and other damage from missiles created by wind forces, loose materials, debris, containers, and vehicles must be relocated (tied down, evacuated, buried).

## **INFORMATION FOR COORDINATORS**

Disasters that cause widespread physical damage (earthquakes, hurricanes, explosions) frequently cause ruptures of pipelines, tanks, chemical containers, fuel drums, which contribute to widespread ignition of fires. These fires are a secondary effect of the disaster that can be reduced by good housekeeping practice. Because fire is so often a major cause of property damage in this type of case, good housekeeping practice is very important. It may simply involve cleaning up and organizing flammable and volatile solvents so containers and transfer lines are less likely to rupture, or to catch fire if they do rupture. With a nuclear weapons disaster, there are other secondary effects that can also be reduced by housekeeping activities. The following list summarizes the major ones:

### **PREVENT SECONDARY EFFECTS --- BY THIS HOUSEKEEPING ACTIVITY**

#### **1. Fires**

Remove and confine or bury combustibles so they cannot ignite or blow about.

Close fuel valves, disconnect vulnerable fuel lines to prevent line rupture and fuel spillage.

Remove drums, cans, small containers of enclosed combustibles (paints, solvents, etc.) to remote location.

Empty above ground fuel storage in raised tanks into below ground storage or drums (then harden as in Booklet 9).

PREVENT SECONDARY EFFECTS ---- BY THIS HOUSEKEEPING ACTIVITY

2. a) **Loose Object Impacts**

Relocate useful unanchored items so they can't become airborne missiles in the high velocity winds. (See Figures 1 and 2)

Remove or bury junk and debris.

b) **Damage or Destruction of Instruments, Controls**

Remove and store in a safe location.

c) **Broken or Ruptured Fuel Lines**

Close main valves, disconnect and empty vulnerable fuel lines.

d) **Hazardous Material Spills**

Remove, bury, or harden hazardous materials containers. Do not empty into sewers! Map locations!

3. **Electrical and Electronic Equipment Burnout**

Disconnect this kind of equipment from incoming power transmission lines, from antennas, and from conducting rails, etc. Communications industries should install EMP protection.

4. **Inaccessibility Due to Deposits of Radioactive Particulates**

Clear debris and non-essentials away from gutters, drains, water channels, and around essential work areas, so that radioactive dust can be hosed off more quickly by recovery crews later.

## DEFINITIONS

**Combustibles** -- Whatever you can ignite using kindling.

**Critical Delicate Gauges, Instruments, Controls** -- Essential items that would be damaged by flying debris or missiles and which you cannot replace, or repair readily with simple tools.

**Vulnerable Fuel Lines** -- An exposed (as opposed to buried) section of fuel line or coolant piping that would probably break if hit by flying debris and would spill combustible fluid.

**Unanchored Objects That Can Become Flying Missiles** -- Gas bottles, stacks or wood and materials, debris boxes, vehicles, etc. Anything that a tornado, or hurricane-like wind could move or lift. (See Figure 1).

## INSTRUCTIONS FOR COORDINATOR

The protective housekeeping plan is divided into two parts: Plant Protective Housekeeping is presented first, followed by Office Protective Housekeeping. These activities can be conducted concurrently. Both parts should be read before starting protective housekeeping activities.

Starting on page 13 is a table that identifies over 100 common chemicals that are a serious hazard. The table is divided into 18 subgroups that are compatible enough within a group they can be stored together. But, between groups, chemicals should be separated, because mixtures across groups may explode, combust, boil, and vaporize, or otherwise react to cause additional rupture and spreading. Note, it is particularly important to isolate the toxic materials so that they will not become a problem during recovery. These should be buried in a trench, if possible, covered, marked, and mapped.

## **PLANT PROTECTIVE HOUSEKEEPING PLAN ELEMENTS**

1. Establish collection points (or final storage points)
  - A A location to collect vulnerable items that require special attention:
    - (1) Gauges, (2) Delicate instruments, (3) Delicate controls, (4) Other.
  - B A location to collect useful but unanchored and less vulnerable items that need to be tied down or immobilized: (1) Gas bottles, (2) Disconnected fuel lines (3) Other.
  - C A location to collect useless junk, combustibles, debris, loose scrap metal, etc., to be disposed of.
  - D A location to collect hazardous materials in drums and packages for hardening.

**Note:** Pick locations that are convenient but that will be out of the way. For example, **A** might best be a truck, for removal to the Host Area, and **B** might be part of a dirt yard area where items could be laid in a ditch or trench to keep them from moving. **C** could be the same, or an unused part of a loading dock if vehicles are available to move such junk to (a) the dump, (b) a ravine, (c) a large ditch. **D** should be an open area, away from structures of any kind, to be hardened as shown in Figure 3. Enough room is needed to ensure adequate space between incompatible groups of chemicals (see Table 1).

2. Organize work and personnel as follows:
  - A Divide outdoor and indoor plant areas into easily **defined regions** so that tasks can be designated without fear of overlapping effort.
  - B Designate **work parties** for these regions to conduct protective housekeeping activities.

- C If your plant is too large to supervise the protective housekeeping yourself, you should establish a fixed, central location for your **control center** in order to be readily available at all times.
- D Establish a record keeper for each work party and, if your plant is large, one messenger for each five work parties to maintain records and liaison. Use the Protective Housekeeping Work Party status forms attached.
- E Establish at least one **troubleshooting and followup team** (more, if the plant is large) to help where and when you decide they are needed. Utilize existing personnel familiar with shutdown procedures used in case of fire and/or explosion.
- F Establish a **tool crib** and allocate tools and equipment among work parties. (Be sure to recover tools as teams finish so they will be available for other operations.)

Note: Make up work parties to cover all regions in two hours, if possible. You will need to assign somebody from the plant maintenance crew to each region, to decide what vulnerable items should be disconnected or disassembled and what is to be considered junk. "Red" flags (or equivalent) should be given to work parties to tag any items passed over; e.g., because the operating crew has not yet completed shutdown. This will make it easier for the followup team to spot and take care of later. The "red tag" system will also help identify where tools will be needed again, later.

3. Explain the whole operation to teams before sending them out. Instruct personnel to report back as tasks are completed. Dispatch work parties when instructions are clear.
4. After about 20 minutes, dispatch messenger(s) to get status reports from each work party -- and report back in 10 minutes or less -- as you will need three to five status reports to keep bottlenecks from forming. Send one messenger to

, each of the four collection points to report the amount of material accumulated there. Use the Storage/Disposal/Harden Status Report form attached.

5. Use your best troubleshooter(s) to follow up work parties to disconnect electronic and electrical equipment that is non-essential now, (and to red tag any still operating for disconnection later). Request a report back in one hour to provide you with a status report.
6. When first round reports are assembled, complete the status report and communicate the information to the plant Hardening Operations Manager.
7. Reassign work parties that finish their region to additional regions, to augment work parties in incompletely regions, or turn them over for reassignment to other coordinators.
8. Have one of your troubleshooters check that coolants and solvents have been removed from metal cutting machinery, etc., and relocated with the hazardous materials.
9. Maintain operations until all tasks are complete and all red tag items completed. A final followup should be made by the best qualified team you can field to ensure that all possible (practical) steps have been taken to reduce or eliminate secondary hazards.
10. When all tasks are complete, have remaining protective housekeeping teams report to plant control center for assignment or dismissal.
11. Draw a map to show locations of each storage/disposal site and contents -- to use during recovery. Make a duplicate map of the hazardous materials site location and contents list. File duplicate with the Host Area authorities -- for use in case of emergency to keep recovery crews out of trouble.
12. Take the other map to the Hardening Operations Manager and give him the final "Storage/Disposal/**Harden** Status Report."

## **OFFICE PROTECTIVE HOUSEKEEPING PLAN ELEMENTS**

**Objective:** To reduce or eliminate vulnerability of plant property to loss or damage by ceasing non-essential onsite office operations and safeguarding vital records.

### **INFORMATION FOR COORDINATOR**

Whether company operations have been designated **Essential** (to be kept running through the crisis) or otherwise, company vital records can be moved from the risk to the host area.

Vital records are defined as irreplaceable, and necessary to functioning of the company. Such records may include processes, blueprints, and manuals; production and sales records; books and ledgers; stockholder lists; computer tapes; etc.

Records ordinarily replaceable (hence not thought vital) may become technically irreplaceable (i.e., not replaceable in time to achieve some important production goal) or virtually irreplaceable (because the replacement source of the records becomes damaged or destroyed).

### **INSTRUCTIONS FOR COORDINATOR:**

Assign task of defining vital records by department, operations center, function, etc. Let the appropriate head of department, foreman, whatever, analyze day-to-day and other periodic operations and list those records without which he feels his department cannot function. Request that he further assess the potential alternatives if these records were destroyed, to see if effective replacement or substitutions can be made -- using items under company control -- that will allow operations to continue. If not, the particular records are **vital** and should be packaged carefully and relocated to a safe area.

It is possible that some records have already been safeguarded by duplicating them and storing in secured locations. In such case, this may be sufficient, particularly for records used infrequently. However, equipment repair manuals, process information, and similar records may be vital to recovery over the short term immediately after the crisis. Such short-term needs should be part of your consideration and planning.

Vital magnetically stored data and computer tapes should be safeguarded in closed metal boxes, to prevent stray fields from damaging them, and removed to a safe location. Again, duplicate records stored in a second, safe location would be highly desirable.

Make an assessment to determine the volume of vital records as well as the total volume of records. Report both figures to the management team so that final disposition can be decided and scheduled.

Make a checklist of utilities (gas, water, steam, electricity) to be turned off before final evacuation; define the sequence and responsibility for final shutoff at the service entrance; red tag the valves, switches, and controls; and draw a map showing the locations of these items.

Offices are particularly vulnerable to fire damage. Most offices have papers stashed in baskets and racks on desks, calendars hanging on walls, waste paper stuffed in waste baskets, etc. Such conditions make the office extremely vulnerable to a thermal pulse from a nuclear weapon. Wrinkled aluminum foil taped to the inside of all windows will reflect the thermal pulse in a fashion that will not be a hazard to others. But, the blast wave may rupture gas lines, cause electrical shorts (if the power is on) and spread papers to catch fire, even if they are put in drawers. Therefore, all papers (including supplies) should be stored and cared for like flammables/combustibles, and the incidence of fires onsite will be reduced.



LP-gas bulk storage and filling plant before a nuclear explosion.



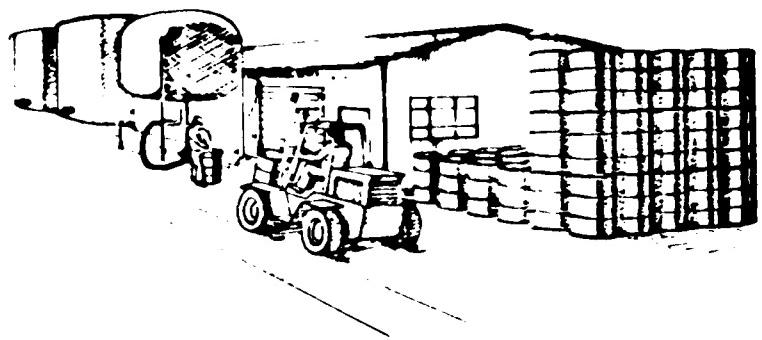
The plant after the explosion (5 psi overpressure).

Fig. 1. EXAMPLE OF THE NEED TO TIE DOWN LOOSE OBJECTS

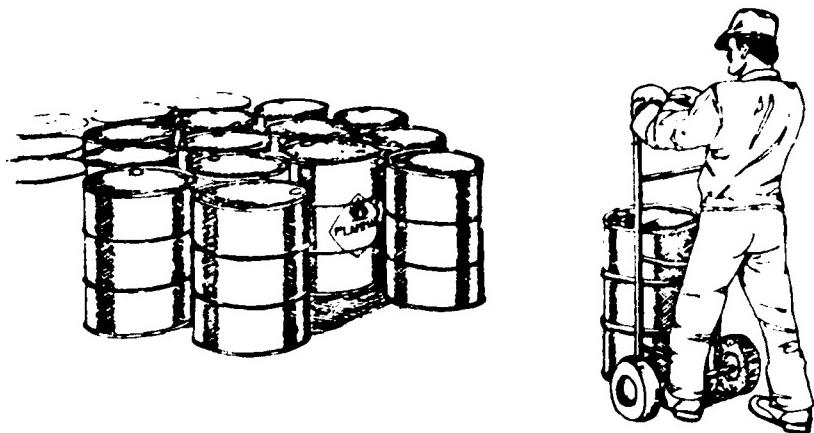


Light missile damage to oil tanks, 0.70 mile from explosion at  
Texas City April 16-17, 1947.

Fig. 2. WHAT MISSILES AND AIRBORNE DEBRIS WILL DO



Drain hazardous materials from vulnerable elevated tanks into drums,



then isolate drums in groups strapped together. Be sure all the materials in any one group are compatible (see Table 1). Otherwise, if drums rupture, reactions may be violent.

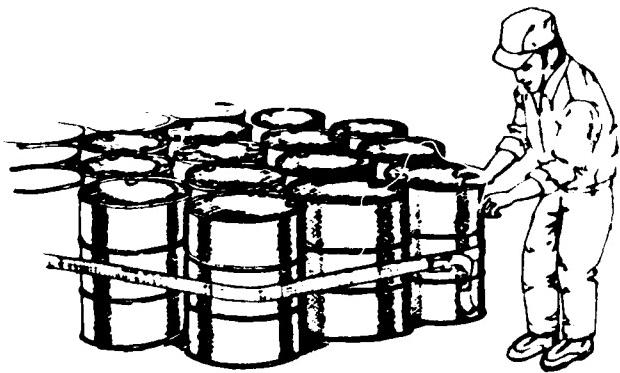


Fig. 3.

TABLE 1: COMMON CHEMICALS

<b>Group I: Hydrocarbons</b>	
a) Gases	b) Liquids
hydrogen	pentane
methane	hexane
ethane	cyclohexane
natural gas	heptane
ethylene	octane
acetylene	benzene
propane	toluene
propylene	xylene
butane	mesitylene
isobutane	ethylbenzene
c) Solid	gasoline
naphthalene	kerosene
	fuel oils
	gasoline (aviation grade)

<b>Group II: Halogenated Compounds</b>	
a) Gases	b) Liquids
methyl chloride	methylene chloride
methyl bromide	chloroform
ethyl chloride	carbon tetrachloride
	ethylene dichloride
	trichloroethane
	trichloroethylene
	chlorobenzene
	dichlorobenzene

<b>Group III: Self-polymerizing Compounds</b>	
a) Gases	b) Liquids
vinyl chloride	formaldehyde-water solution
vinyl bromide	acetaldehyde
butadiene	acrolein
formaldehyde	acrylonitrile
	vinyl acetate
	isoprene
	styrene
	methyl acrylate
	methyl methacrylate
	turpentine

**Group IV: Oxides and Peroxide-forming compounds****a) Gases**

ethylene oxide  
dimethyl ether

**b) Liquids**

propylene oxide  
diethyl ether  
tetrahydrofuran  
dioxane  
dimethoxy ethane  
diisopropyl ether

**Group V: Combustible Compounds****a) Non-toxic liquids**

methanol  
ethanol  
acetone  
methyl ethyl ketone  
ethyl acetate  
dimethyl sulfoxide  
propyl alcohol  
isopropyl alcohol  
butanol

**b) Toxic liquids**

methyl mercaptan  
acetonitrile  
dimethyl sulfate

**c) Solid**

phenol

**Group VI: Bases****a) Gases**

ammonia, anhydrous  
methylamine

**b) Liquids**

ethanolamine  
ethylenimine  
aniline  
pyridine

**c) Solids**

sodium hydroxide  
potassium hydroxide

**Group VII: Acids A**

acetic acid  
phosphoric acid

**Group VIII: Acids B - Oxidizers****a) Gas**

nitrogen tetroxide

**b) Liquids**

nitric acid  
perchloric acid\*

\*store protected from sun.

**Group IX: Acids C**

chlorosulfonic acid

**Group X: Acid D**

sulfuric acid

**Group XI: Poison A****a) Gases**

hydrogen chloride  
hydrogen fluoride  
carbon monoxide  
hydrogen sulfide  
phosgene

**b) Liquids**

hydrogen cyanide  
carbon disulfide  
hydrochloric acid  
acetone cyanohydrin

**Group XII: Poison B - Miscellaneous****a) Gases**

sulfur dioxide  
chlorine  
boron trifluoride

**b) Liquids**

bramine

**Group XIII: Poison C****Liquid**

tetraethyl lead

**Group XIV: Poison D****Gas**

fluorine

**Group XV: Poison E****Solid**

phosphorus red  
phosphorus white or  
yellow

**Group XVI: Oxidizers****Solid**

ammonium nitrate  
ammonium perchlorate

**Group XVII: Metals and Derivatives****Solid**

lithium  
sodium  
potassium  
magnesium  
calcium hydride

**Group XVIII: Non-Metals Derivatives****a) Liquids**

sulfur trioxide, oleum  
sulfuryl chloride  
thionyl chloride  
phosphorus trichloride  
phosphorus oxychloride  
titanium tetrachloride

**b) Solids**

phosphorus pentoxide  
phosphorus pentasulfide

**PROTECTIVE HOUSEKEEPING WORK PARTY STATUS FORM**

## PROTECTIVE HOUSEKEEPING WORK PARTY STATUS FORM

## **PROTECTIVE HOUSEKEEPING WORK PARTY STATUS FORM**

## PROTECTIVE HOUSEKEEPING WORK PARTY STATUS FORM

## PROTECTIVE HOUSEKEEPING WORK PARTY STATUS FORM

STORAGE/DISPOSAL STATUS REPORT

Time: \_\_\_\_\_

Estimated Time to Complete: \_\_\_\_\_

Estimated Percentage Completed: \_\_\_\_\_

Size of Present Debris Pile: \_\_\_\_\_

Size of Present Delicate Equipment Collection: \_\_\_\_\_

Size of Present Heavy Equipment Collection: \_\_\_\_\_

Size of Present Hazardous Materials Collection: \_\_\_\_\_

ALTERNATIVE SOLUTIONS FOR SAFE STORAGE OR DISPOSAL:

	MOVE *	BURY *	TIE DOWN *
DEBRIS			
DELICATE EQUIPMENT			
HEAVY EQUIPMENT			
HAZARDOUS MATERIALS			

\* In each box, list resources required and estimated time to complete.

STORAGE/DISPOSAL STATUS REPORT

Time:

Estimated Time to Complete:

Estimated Percentage Completed:

Size of Present Debris Pile:

Size of Present Delicate Equipment Collection:

Size of Present Heavy Equipment Collection:

Size of Present Hazardous Materials Collection:

ALTERNATIVE SOLUTIONS FOR SAFE STORAGE OR DISPOSAL:

	MOVE *	BURY *	TIE DOWN *
DEBRIS			
DELICATE EQUIPMENT			
HEAVY EQUIPMENT			
HAZARDOUS MATERIALS			

\* In each box, list resources required and estimated time to complete.

STORAGE/DISPOSAL STATUS REPORT

Line:

Estimated Time to Complete:

Estimated Percentage Completed:

Size of Present Debris Pile:

Size of Present Delicate Equipment Collection:

Size of Present Heavy Equipment Collection:

Size of Present Hazardous Materials Collection:

ALTERNATIVE SOLUTIONS FOR SAFE STORAGE OR DISPOSAL:

	MOVE *	BURY *	TIE DOWN *
DEBRIS			
DELICATE EQUIPMENT			
HEAVY EQUIPMENT			
HAZARDOUS MATERIALS			

\* In each box, list resources required and estimated time to complete.

DEBRIS/DETERIORATE STATUS REPORT

Date:

Estimated Time to complete:

Estimated Percentage Completed:

Size of Present Debris Pile:

Size of Present Delicate Equipment Collection:

Size of Present Heavy Equipment Collection:

Size of Present Hazardous Materials Collection:

ALTERNATIVE OPTIONS FOR SAFE STORAGE OR DISPOSAL:

	MOVE *	bury *	TIE DOWN *
DEBRIS			
DELICATE EQUIPMENT			
HEAVY EQUIPMENT			
HAZARDOUS MATERIALS			

\* In each box, list resources required and estimated time to complete.

# **INDUSTRIAL PROTECTION GUIDE**

**CRISIS RELOCATION  
INDUSTRIAL HARDENING PLAN**

**PROVIDENCE  
INDUSTRIAL**

**INDUSTRIAL**

## **CRISIS RELOCATION INDUSTRIAL HARDENING PLAN**

Booklet 5

### **HARDENING RESOURCES INVENTORY**

This is one of ten booklets of the Industrial Hardening Manual  
developed for the  
Federal Emergency Management Agency  
under Contract No. EMW-C-0154, Work Unit 1124E

**SCIENTIFIC SERVICE, Inc.**  
Redwood City, California 94063

Booklet 5

**HARDENING RESOURCES INVENTORY**

Coordinator: \_\_\_\_\_  
(name)

Alternate: \_\_\_\_\_  
(name)

**Objective:** To develop a list of resources available to your plant for "hardening" and recovery.

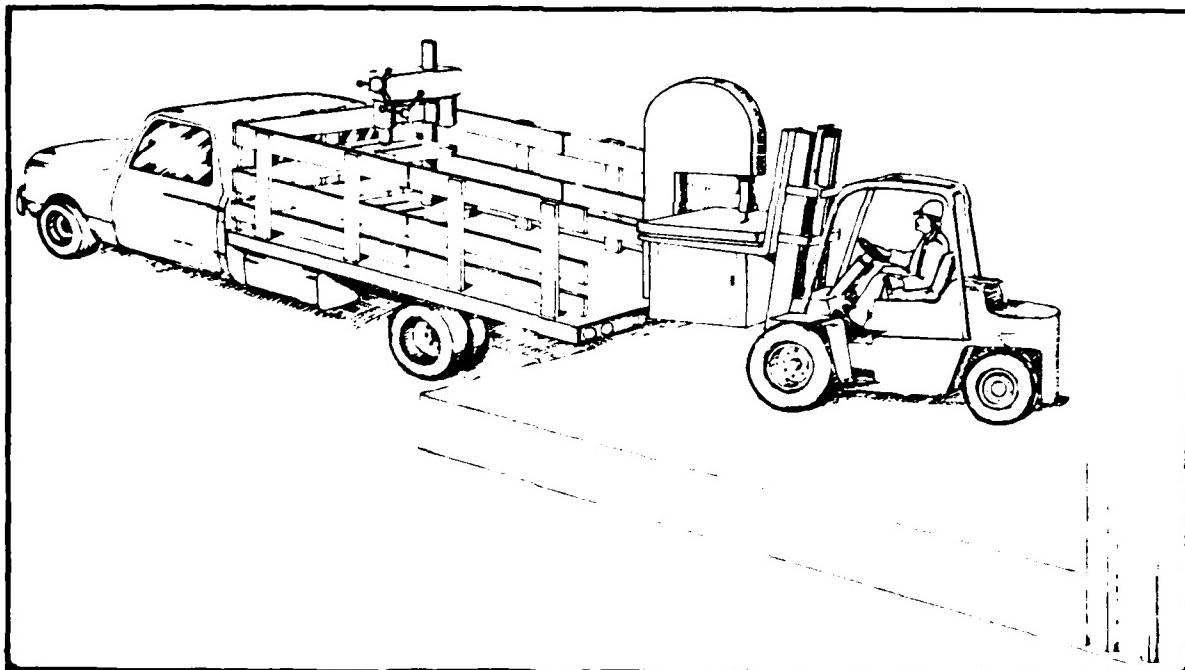
This booklet is part of a plan to protect industrial plant equipment from possible damage in the event of a nuclear attack. It leads to a surveyed list of resources available to carry out the various plan elements that might be developed to harden the facility and to return it rapidly to production after the crisis is over. Hardening alternatives involve the movement of personnel, records, equipment to low-risk (non-target) areas; construction of revetments, berms, burial pits for equipment; lashing down packaged and cushioned equipment with cable, rope, chain link fencing; disassembly of vulnerable structures, etc. Returning the facility to production requires tools, materials handling equipment, power distribution systems, etc., which may no longer be functioning or available, if left onsite. These resources should be evacuated to the host area so they will be in your hands when you are ready for them.

In the first few pages of this booklet you will find some illustrations of methods for protecting (hardening) plant equipment. These illustrations will help you to identify the resources to be inventoried. Similar illustrations have been provided to distribute with the inventory forms included in the last part of this booklet to help you inventory resources in your plant quickly and efficiently.

The Coordinator assigned to direct the taking of this inventory should review the total concept of industrial hardening with management. Because materials and equipment on hand may change frequently, this inventory will have to be current at the time hardening is to commence.

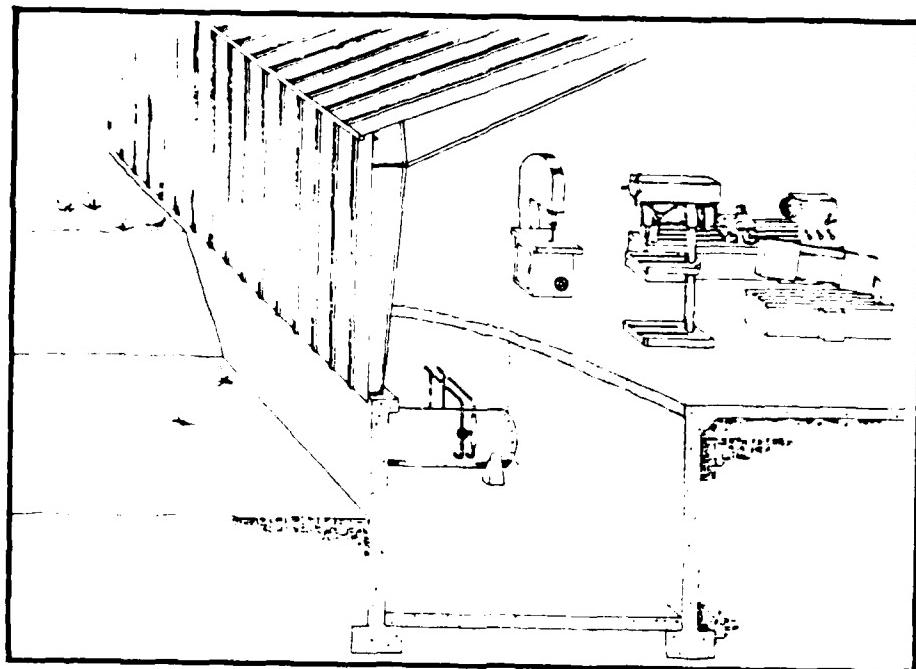
**IN THE PRESENT CRISIS**

To protect (harden) equipment needed for continued survival,  
resources are required to do the following.



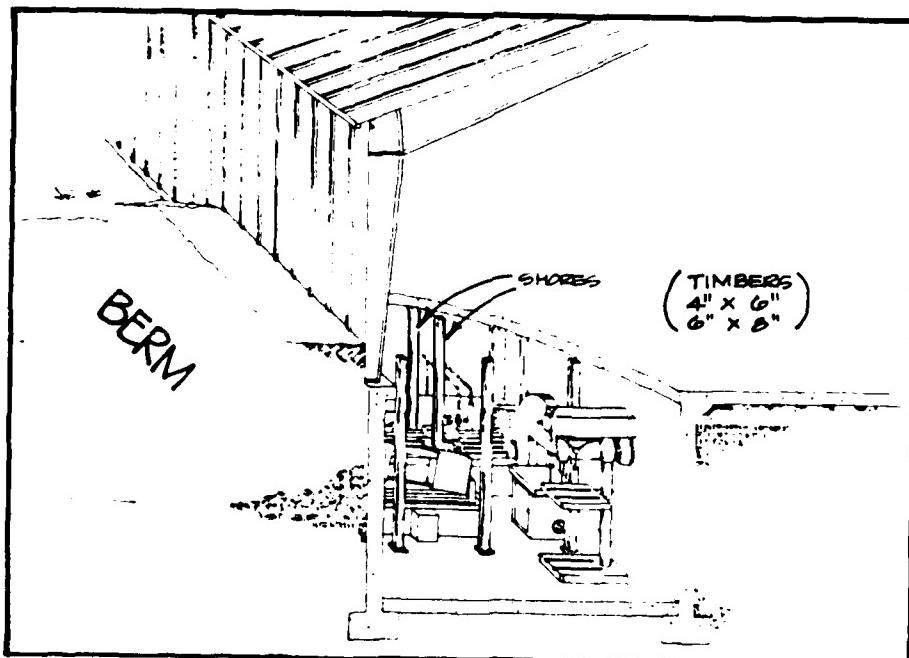
**LOAD EQUIPMENT AND MOVE IT AWAY**

MOVE EQUIPMENT TO SAFER PLACE IN THE PLANT STRUCTURE  
AND HARDEN STRUCTURE . . .



TO HARDEN STRUCTURE  
(It Must Have a Basement!)

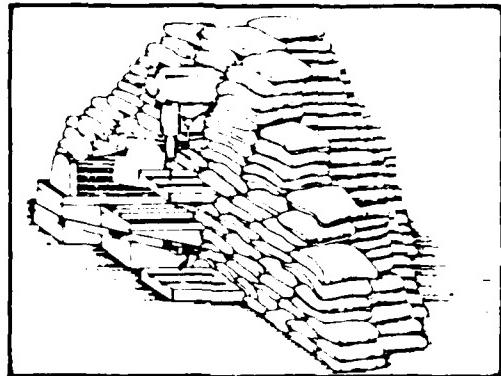
Reinforce basement space with supporting timbers (shores). Berm outside walls to floor line.



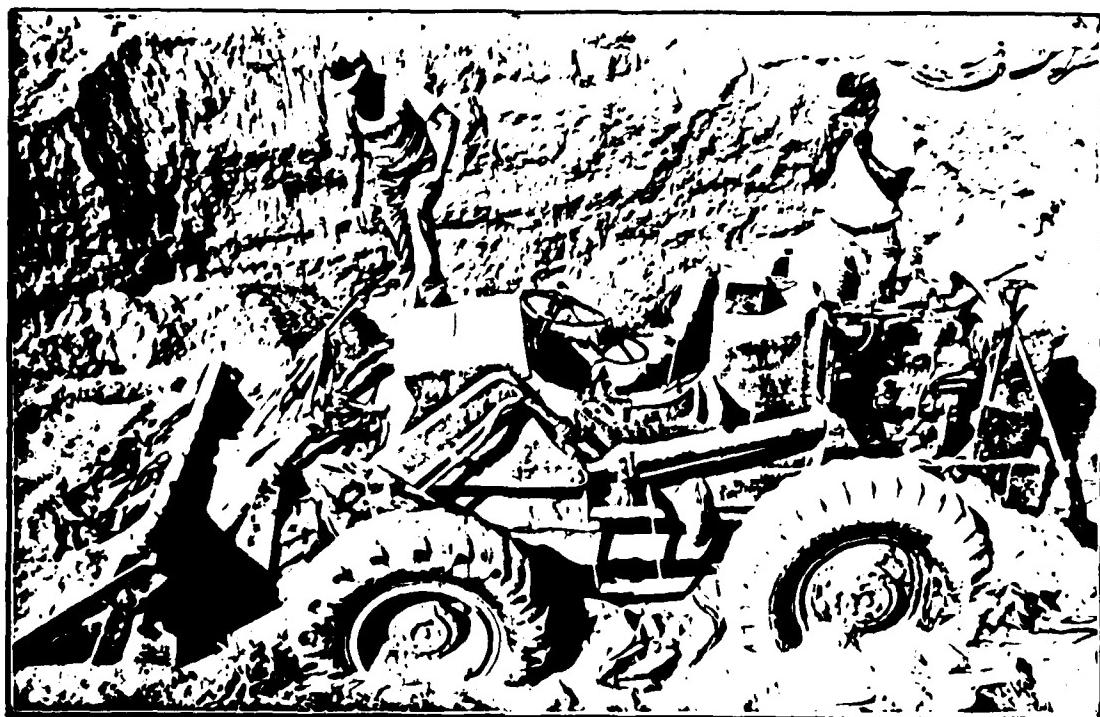
RELOCATE EQUIPMENT UNDERGROUND IN SHORED BASEMENT

IF YOU CAN MOVE THE EQUIPMENT BUT CAN'T HAUL IT AWAY . . .

BURY IT OUTDOORS

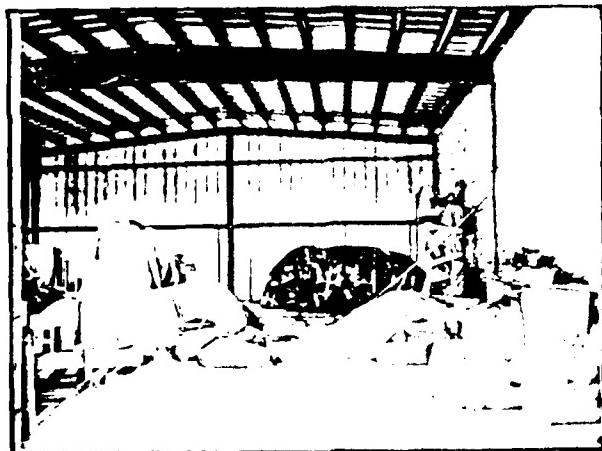


In Paved Areas - Sandbag It

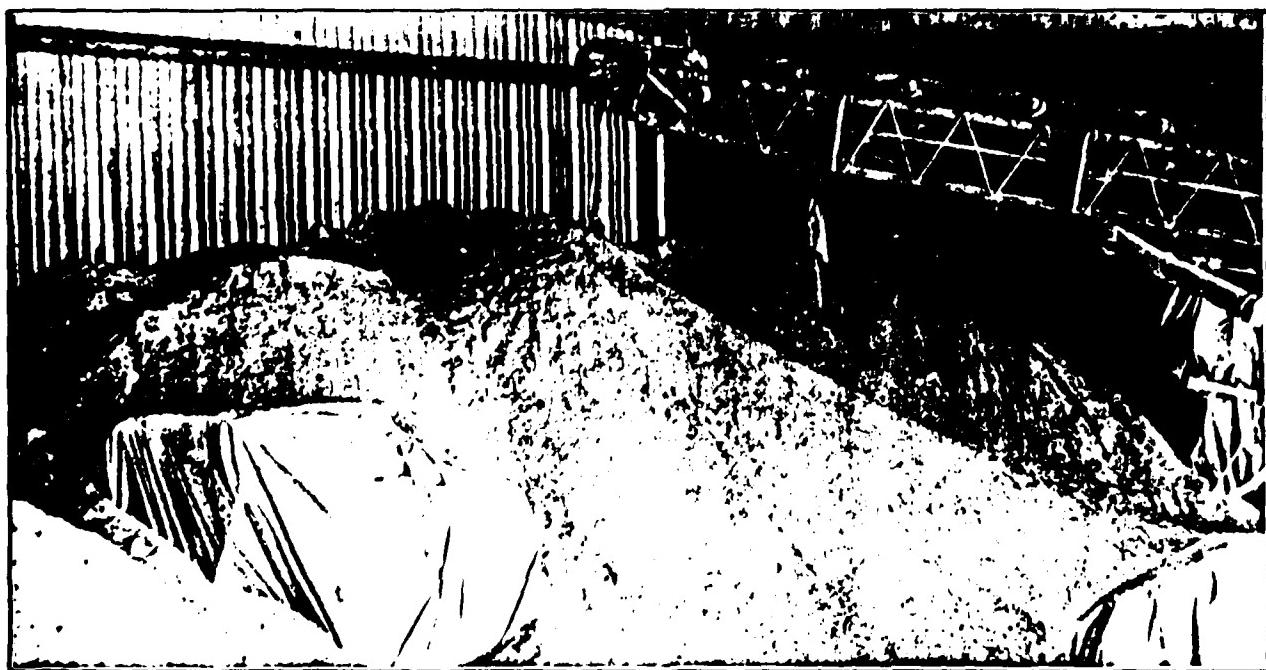


IN OPEN AREAS - PUT IT IN A TRENCH  
(COVER IT IF THERE IS TIME)

IF YOU CAN'T MOVE EQUIPMENT . . .

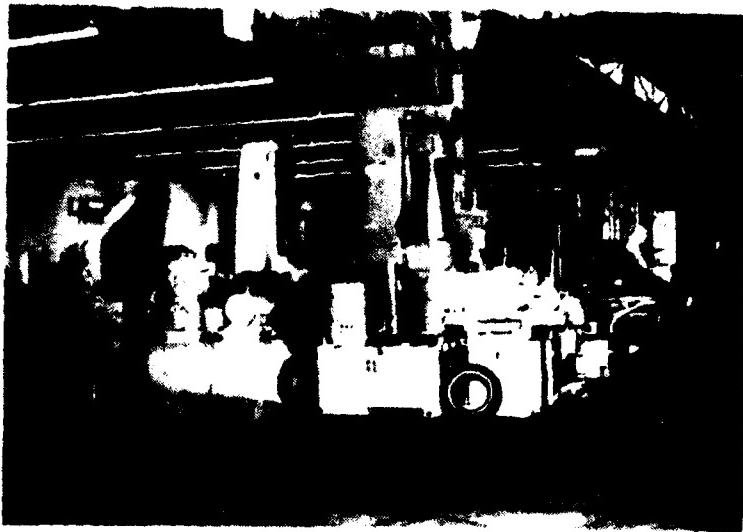


Crushable packing held in place by plastic sheet  
for burial protection.

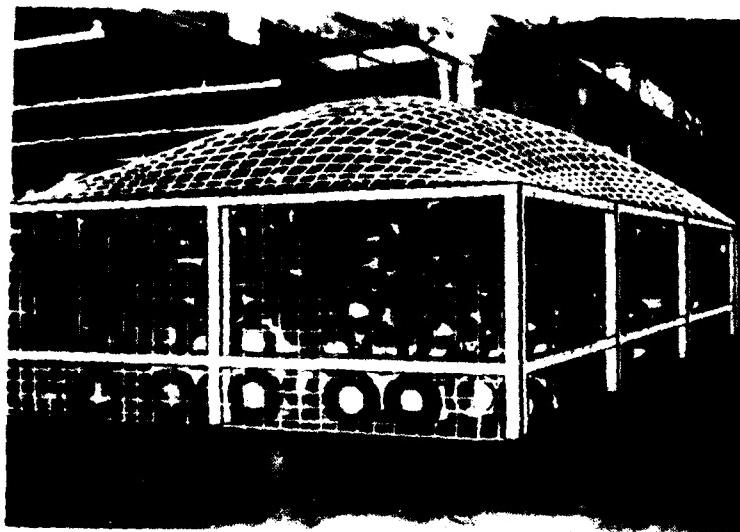


BURY IT IN-PLACE INDOORS.

IF YOU CAN'T BURY OR MOVE IT . . .



Cluster movable equipment around it; wedge wood or tire bumpers between equipment to protect knobs, handles, etc.



Weld I-beam crib around it; add chain link fence; stuff with tires or lumber; and cover.

**INSTRUCTIONS FOR COORDINATOR:**

To inventory and list the materials and equipment previously pictured, the following plan can be put into effect.

Divide your facility into areas. Choose areas so resources in each can be inventoried in approximately one or two hours.

Divide available personnel into two-man teams, so that each team covers an area, and assign a team leader and a recorder; where possible, assign personnel familiar with the area covered.

Detach forms and distribute to the teams. (Forms are in the back of this booklet.)

A sample of a completed form can be found on page 12 of this booklet.

Review the instructions here and on the following page with each team, then:

Select a coding system for tagging resources so all resources of one type have the same mark, tag, or color.

If sufficient personnel are available, consider a roving supervisor between teams. This person can aid some teams that may falter; he should be someone familiar with the total plan.

Again if sufficient personnel are available, appoint a runner to collect and return completed forms to you.

Return the completed forms to the Hardening Operations Manager.

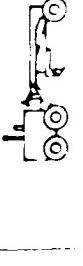
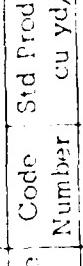
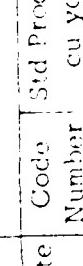
### **OFFSITE RESOURCES:**

If sufficient personnel are available, or at the end of the onsite inventory, a team or two should be assigned the task of assessing the offsite resources that are available for use. In most industrial complexes it is likely that a variety of facilities exist, each with different types of equipment and supplies. Arrangements to use needed outside resources should be made either through previously arranged mutual aid agreements or by on-the-spot trades.

Examples of trades or exchanges might be: Temporary use of a forklift in exchange for packing materials; spare cable for sand and gravel; or excess labor for any needed commodity.

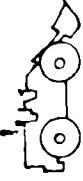
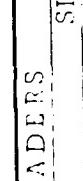
All offsite resources should be identified on a separate resource sheet and all trades should be coordinated through the management team.

**STANDARD EQUIPMENT RATE - PRIMARY EQUIPMENT**

CRAWLER		WHEEL		SIDE-DUMPER	
					
Horsepower Rating	Code Number	Std Prod Rate cu yd/hr	Code Number	Std Prod Rate cu yd/hr	Code Number
Up to 150	240	140	-	141	160
150 to 200	242	230	283	143	200
200 to 250	244	330	285	145	280
250 to 300	246	400	297	-	-
Cover 300	248	520	299	350	-
				530	-

Horsepower Rating	Code Number	Std Prod Rate cu yd/hr	Code Number	Std Prod Rate cu yd/hr	Code Number	Std Prod Rate cu yd/hr
Up to 150	240	100	161	130	170	125
150 to 200	162	140	153	105	172	100
200 to 250	164	185	165	250	174	215
250 to 300	166	245	167	300	176	200
Cover 300	-	-	169	430	-	177

Table from "What the Planner Needs to Know," Jacobs Associates, San Francisco, June 1975.

FRONT-END LOADERS		SIDE-DUMP		END-DUMP	
CRAWLER		WHEEL		CRAWLER	
					
Horsepower Rating	Code Number	Std Prod Rate cu yd/hr	Code Number	Std Prod Rate cu yd/hr	Code Number
Up to 150	169	100	161	130	170
150 to 200	162	140	153	105	172
200 to 250	164	185	165	250	174
250 to 300	166	245	167	300	176
Cover 300	-	-	169	430	177

For those who wish to barter for use of equipment, this table indicates production rates (in cubic yards per hour) that can be moved around in a plant by a qualified operator).

#### **INVENTORY FOR RECOVERY:**

Equipment will be required to remove the debris from protected production equipment. Winches, bulldozers, etc., will be needed to uncover the equipment, and maintenance and repair tools, maintenance and repair manuals, etc., will be needed to get equipment back into operation.

Equipment that will be required during the recovery period will include some of that used during hardening. This inventory should be divided into two lists: one list should contain those items needed for post-attack recovery that will also be used for hardening. The other list should contain only those items critical to recovery that will not be needed until then, such as maintenance and repair tools, repair manuals, spare parts, fuel, truck-mounted winches. These may be evacuated early. The former list of recovery equipment will have to be scheduled for later evacuation.

Only that equipment required for recovery that you can easily dig out later with evacuated tools and resources should be hardened onsite -- otherwise recovery equipment should be evacuated, or it may become buried in rubble and inaccessible.

**INSTRUCTIONS FOR TEAM MEMBERS:**

Collect necessary equipment: Clipboard, or equivalent, pencils or pens, measuring tool, and inventory forms to compile the inventory. There are seven sets of inventory forms for listing seven categories of resources.

Take flags, markers, or spray paint to mark items inventoried to avoid double counting or missing of items. Seven different marking codes will simplify allocations of resources later.

Use a different form for each type of resource being inventoried and code all items in one category with the same marking. Use illustrations and lists provided with each set of forms to help you decide what to list in each category.

Enter your team number, the location of the area inventoried, the number of the sheet completed, and the color code or other method of identifying the material in the category you have inventoried.

Write brief descriptions of the items or groups of items and their locations.

Estimate quantity and size of stacks or piles of materials; don't take time to count every piece.

Return completed forms to the Coordinator.

## RESOURCE INVENTORY SHEET

HEAVY DUTY MATERIALS & EQUIPMENT FOR COVERING & BURYING TEAM # 3AREA Bldg. 112A CODE (IF USED) Red SHEET # 1

ITEM #	DESCRIPTION & LOCATION	QUANTITY
<u>1</u>	<u>Debris box 2 yds capacity Bay 4</u>	<u>3</u>
<u>2</u>	<u>FORK lift 4,000 lbs Bay 5</u>	<u>2</u>
<u>3</u>	<u>CONVEYOR 25' with motor Bay 6</u>	<u>1</u>
<u>4</u>	<u>PRECAST slabs 8" x 4' x 16'</u> <small>yard behind building</small>	<u>about 50</u>
<u>5</u>	<u>" " 6" x 4' x 12"</u>	<u>about 30</u>
<u>6</u>	<u>PRECAST columns 1' x 2' x 12"</u>	<u>about 150</u>
<u>7</u>	<u>CEMENT sacks 100 lbs Back shed</u>	<u>about 80</u>
<u>8</u>	<u>PRECAST forms misc. Yard</u>	<u>cover about 1,000 ft<sup>2</sup></u>
<u>9</u>		
<u>10</u>		
<u>11</u>		
<u>12</u>		
<u>13</u>		
<u>14</u>		

## **RESOURCE INVENTORY FORMS**

1. For Lifting, Moving, Transportation
2. Shelter Construction/Upgrading
3. Ditching & Berming
4. Crushable Materials & Light Covering Material
5. Heavy Duty Materials & Equipment  
for Covering & Burying
6. For Fastening and Anchoring
7. Recovery

POP LIFTING, MOVING, TRANSPORTATION



Highway

stake truck  
flat bed  
U-haul trailer  
van  
tanker  
dump truck  
cement truck  
dumpster

Rail

flatcar  
boxcar  
hopper car  
tank car

Waterways

barge  
garbage scow  
raft  
ferry



In Plant

crane  
gantry  
forklift  
endloader  
cherry picker  
jacks  
bridge crane  
rollers

RESOURCE INVENTORY SHEET

FOR LIFTING, MOVING, TRANSPORTING

TEAM # \_\_\_\_\_

AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_

ITEM #      DESCRIPTION & LOCATION      QUANTITY

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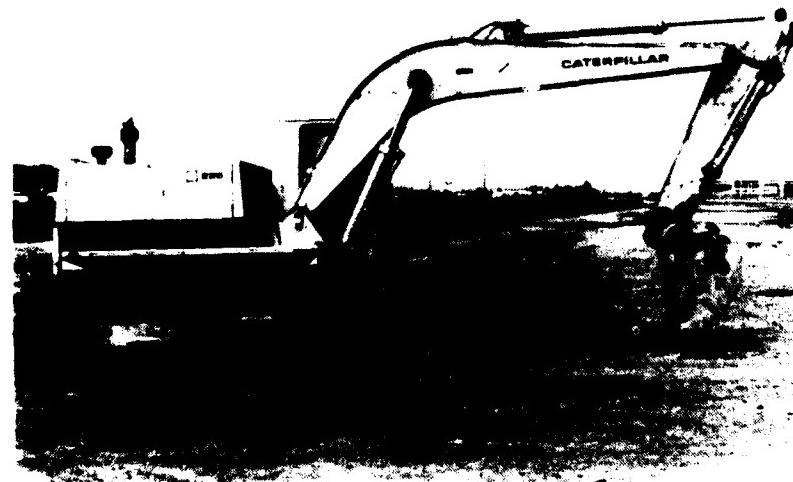
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SHELTER CONSTRUCTION/UPGRADING



Equipment

shovel  
conveyor  
wheelbarrow  
endloader  
grader  
backhoe  
tractor  
picks  
saws

Materials

nails  
plywood  
lumber  
railway ties  
pipe  
concrete block  
precast concrete  
winches

RESOURCE INVENTORY SHEET

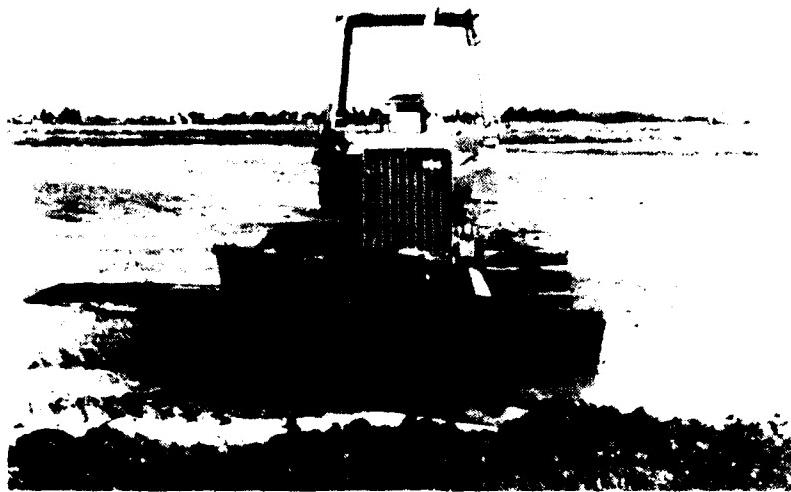
**SHELTER CONSTRUCTION/UPGRADING**

TEAM # \_\_\_\_\_

AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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14		

DITCHING & BERMING



Equipment  
grader  
end loader  
ditch diggers  
scrapers  
trucks  
backhoes  
tractors

RESOURCE INVENTORY SHEET

DITCHING & BERMING EQUIPMENT

TEAM # \_\_\_\_\_

AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_

ITEM #      DESCRIPTION & LOCATION      QUANTITY

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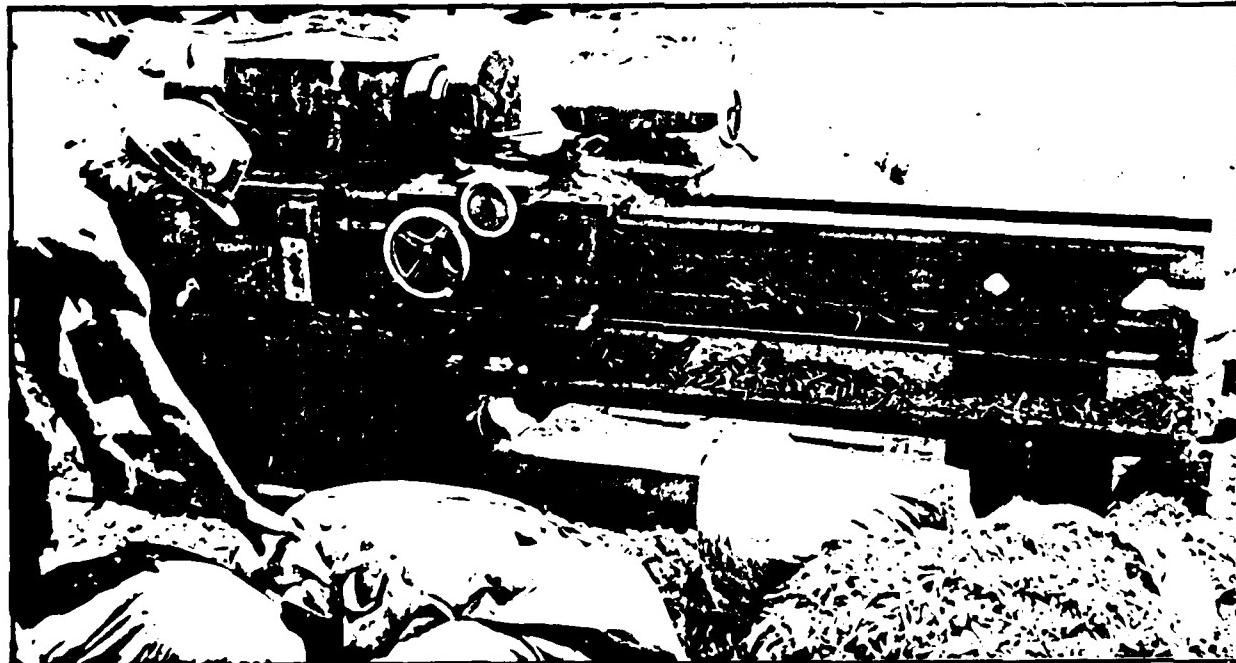
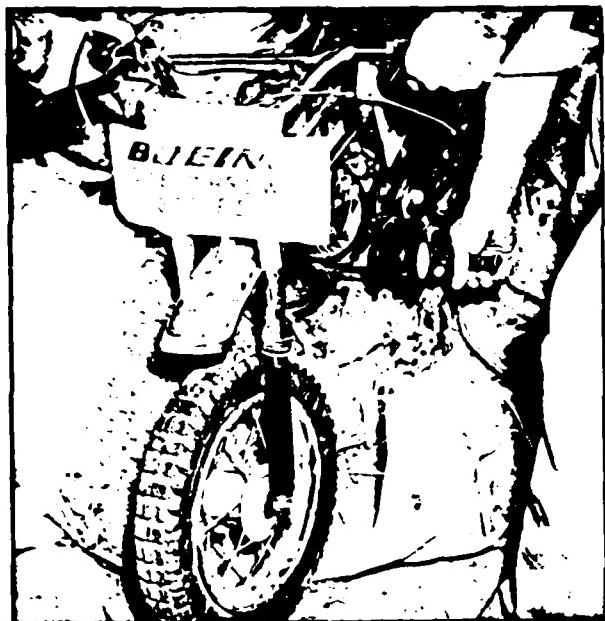
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CRUSHABLE PACKING MATERIAL AND LIGHT COVERING MATERIAL



- CRUSHABLE PACKING -

HAY  
STRAW  
EXCELSIOR  
METAL SHAVINGS  
WOOD CHIPS

PAPER  
CARDBOARD  
STYROFOAM  
FIBERGLAS BATS  
PERLITE

- LIGHT COVERING -

MICA  
MINERAL WOOD  
CORK BOARD  
GRAIN  
SAWDUST  
TIRES

TAR PAPER  
RUBS  
SHEETS  
PLASTIC FILM

NEWSPRINT  
LINOLEUM  
CANVAS  
RUBBER SHEETING

RESOURCE INVENTORY SHEET

**CRUSHABLE MATERIALS & LIGHT COVERING MATERIAL**

TEAM # \_\_\_\_\_

AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_

ITEM #	DESCRIPTION & LOCATION	QUANTITY
1	_____	_____
2	_____	_____
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4	_____	_____
5	_____	_____
6	_____	_____
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13	_____	_____
14	_____	_____

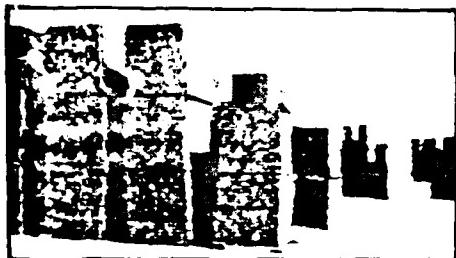
## HEAVY DUTY MATERIALS AND EQUIPMENT FOR COVERING AND BURYING



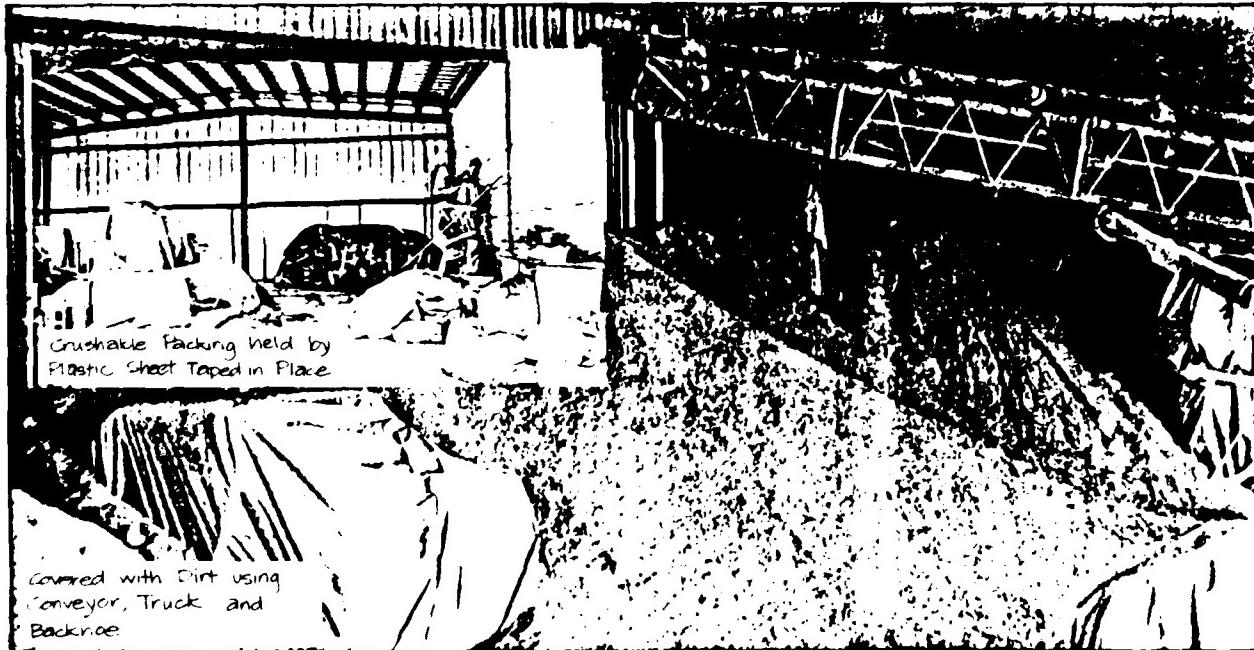
BULLDOZER



PRECAST CONCRETE SLABS AND COLUMNS ; END LOADER



LUMBER STACKS



### MATERIALS

DIRT  
SAND  
GRAVEL  
PLYWOOD  
LUMBER

CONCRETE SLABS  
CONCRETE PIERS  
METAL PLATES  
BRICK  
CONCRETE BLOCK

COAL  
RUBBLE  
CHAIN LINK FENCE  
SAND BAGS  
CEMENT SACKS

### EQUIPMENT

BULLDOZER  
END LOADER  
SNOW PLOW  
GRADER  
TRACTOR

CONVEYOR  
FORK LIFT  
WITH DEBRIS BOX  
DUMPSTER

**RESOURCE INVENTORY SHEET**

**HEAVY DUTY MATERIALS & EQUIPMENT FOR COVERING & BURYING    TEAM # \_\_\_\_\_**

**AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_**

**ITEM #                  DESCRIPTION & LOCATION                  QUANTITY**

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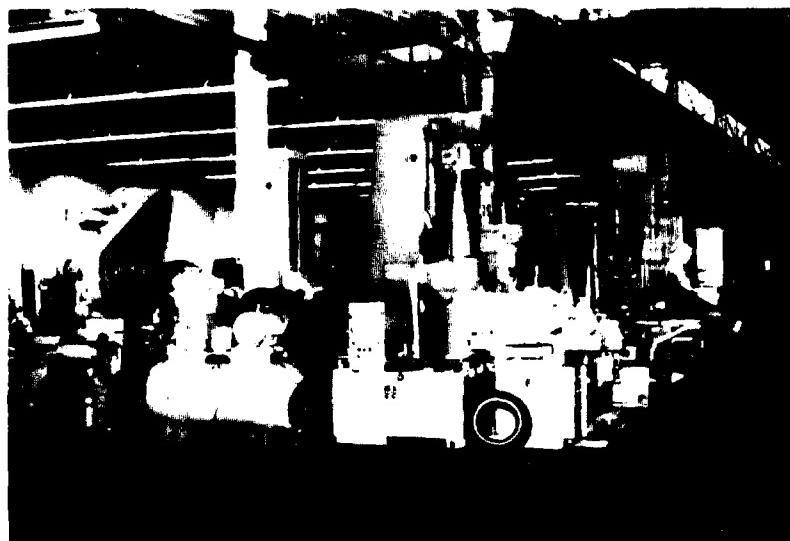
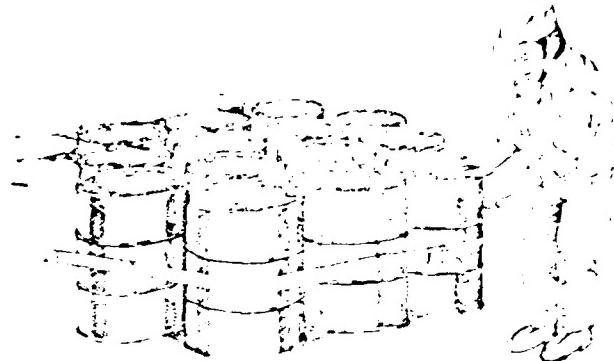
**11** \_\_\_\_\_

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**13** \_\_\_\_\_

**14** \_\_\_\_\_

FOR FASTENING AND ANCHORING

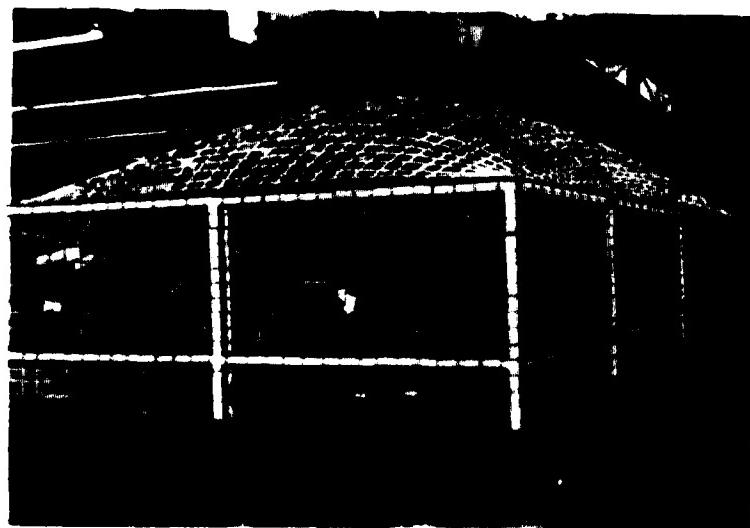


Fastening Materials

wire  
cable  
truckee strapping  
webbing  
reinforcing wire  
beams and channel  
welding rod  
chain link fence  
cable clamps  
turnbuckle

Anchors

pipe  
angle iron  
rebar  
light standards  
telephone poles  
concrete blocks



RESOURCE INVENTORY SHEET

**PASTENING & ANCHORING**

TEAM #   

AREA                          CODE (IF USED)                          SHEET #             

ITEM #      DESCRIPTION & LOCATION      QUANTITY

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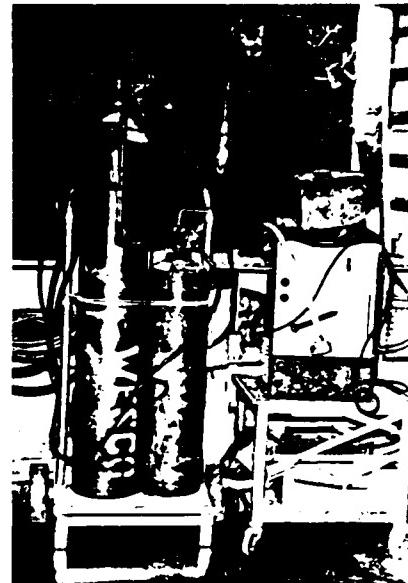
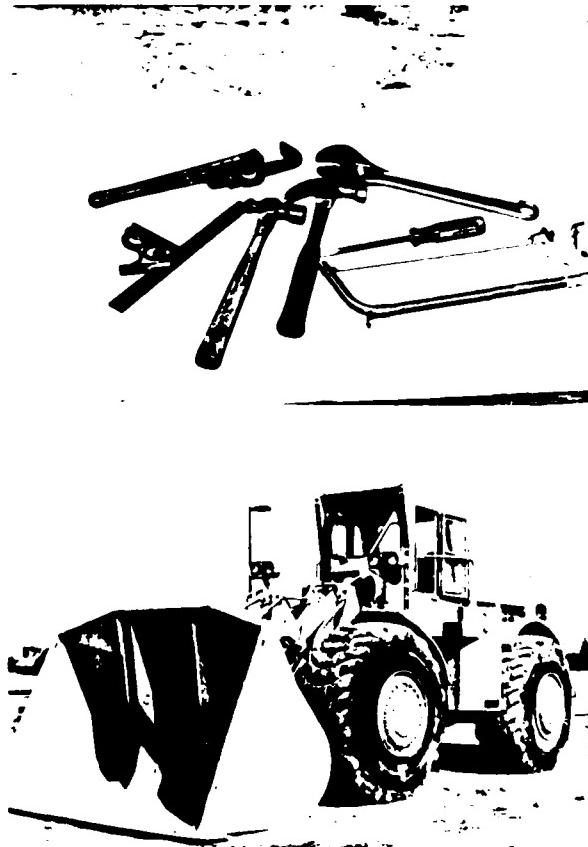
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## RECOVERY



### Lifting & Moving Equipment

A-frame  
backhoe  
end loader  
winch  
tractor  
truck  
bulldozer

### Maintenance & Repair

welder  
torch  
hand torch  
machine tools  
hand tools  
equipment manual  
repair manual  
grinder  
generator

### Safety

radiac equipment  
disposable work clothes  
mobile pump units  
water tankers  
ditching equipment

**RESOURCE INVENTORY SHEET**

**RECOVERY**

**TEAM #** \_\_\_\_\_

**AREA** \_\_\_\_\_ **CODE (IF USED)** \_\_\_\_\_ **SHEET #** \_\_\_\_\_

**ITEM #**      **DESCRIPTION & LOCATION**      **QUANTITY**

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TOP LIFTING, MOVING, TRANSPORTATION



Highway

stake truck  
flat bed  
U-haul trailer  
van  
tanker  
dump truck  
cement truck  
dumpster

Rail

flatcar  
boxcar  
hopper car  
tank car

Waterways

barge  
garbage scow  
raft  
ferry



In Plant

crane  
gantry  
forklift  
endloader  
cherry picker  
jacks  
bridge crane  
rollers

RESOURCE INVENTORY SHEET

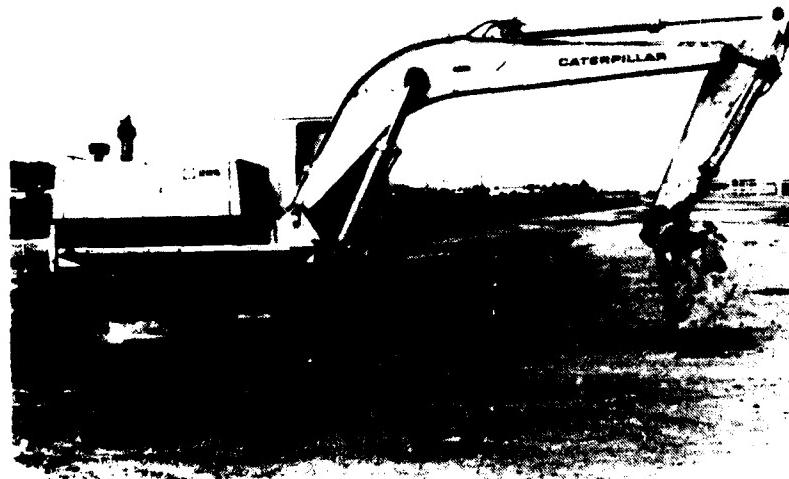
FOR LIFTING, MOVING, TRANSPORTING

TEAM #   

AREA                          CODE (IF USED)                          SHEET #             

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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SHELTER CONSTRUCTION/UPGRADING



Equipment

shovel  
conveyor  
wheelbarrow  
endloader  
grader  
backhoe  
tractor  
picks  
saws

Materials

nails  
plywood  
lumber  
railway ties  
pipe  
concrete block  
precast concrete  
winches

**RESOURCE INVENTORY SHEET**

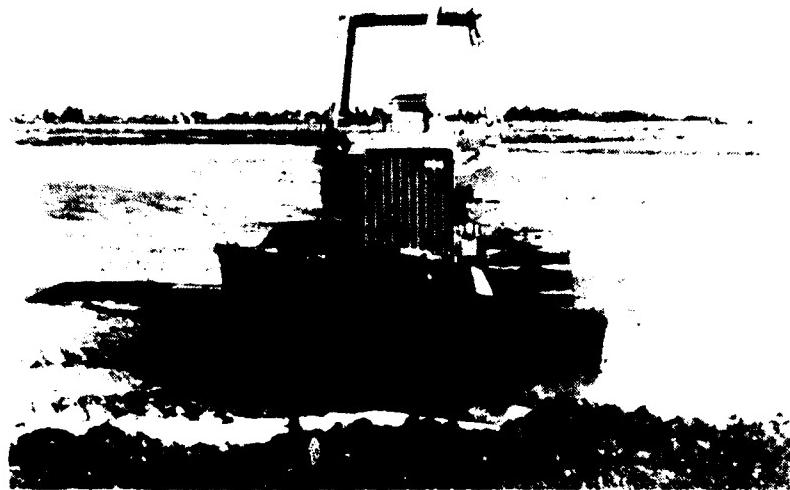
**SHELTER CONSTRUCTION/UPGRADING**

**TEAM #** \_\_\_\_\_

**AREA** \_\_\_\_\_ **CODE (IF USED)** \_\_\_\_\_ **TEAM #** \_\_\_\_\_

<b>ITEM #</b>	<b>DESCRIPTION &amp; LOCATION</b>	<b>QUANTITY</b>
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DITCHING & BERMING



Equipment  
grader  
end loader  
ditch diggers  
scrapers  
truck  
backhoe  
tractors

RESOURCE INVENTORY SHEET

DITCHING & BERMING EQUIPMENT

TEAM # \_\_\_\_\_

AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_

ITEM #      DESCRIPTION & LOCATION      QUANTITY

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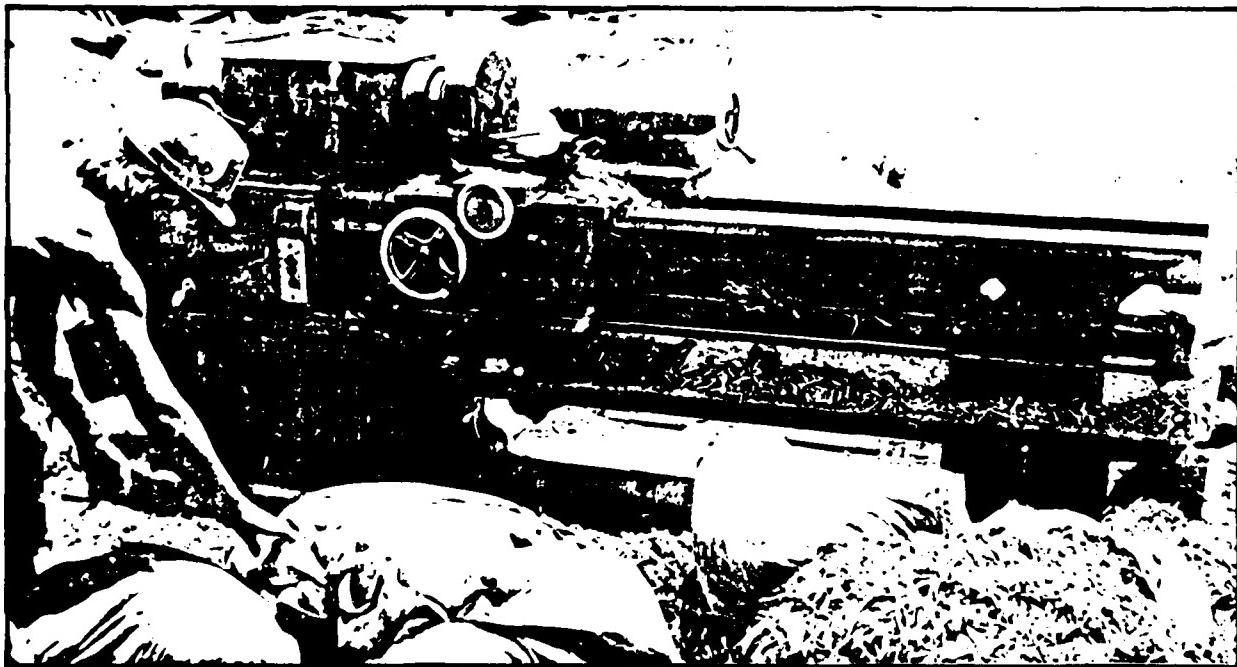
11 \_\_\_\_\_

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CRUSHABLE PACKING MATERIAL AND LIGHT COVERING MATERIAL



- CRUSHABLE PACKING -

HAY PAPER  
STRAW CARDBOARD  
EXCELSIOR STYROFOAM  
METAL SHAVINGS FIBERGLAS BATTS  
WOOD CHIPS PERLITE

- LIGHT COVERING -

MICA TAR PAPER NEWSPRINT  
MINERAL WOOD RUGS LINOLEUM  
CORK BOARD SHEETS CANVAS  
GRAIN PLASTIC FILM RUBBER SHEETING  
SAWDUST TIRES

RESOURCE INVENTORY SHEET

**CRUSHABLE MATERIALS & LIGHT COVERING MATERIAL**

TEAM #   

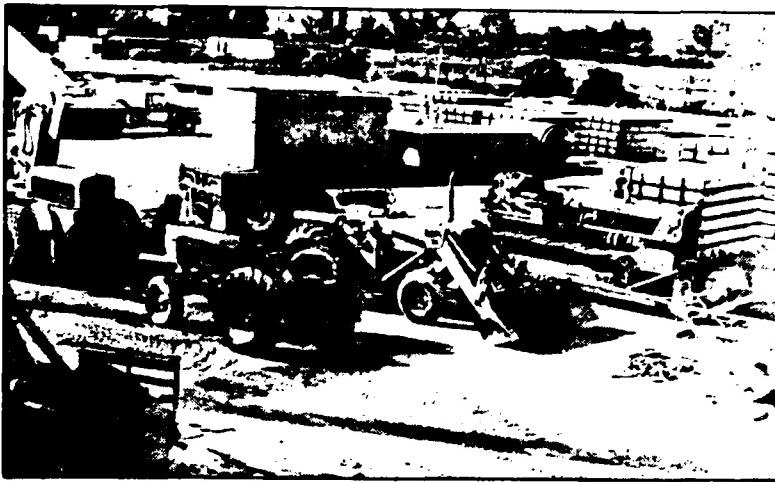
AREA                          CODE (IF USED)                          SHEET #             

<u>ITEM #</u>	<u>DESCRIPTION &amp; LOCATION</u>	<u>QUANTITY</u>
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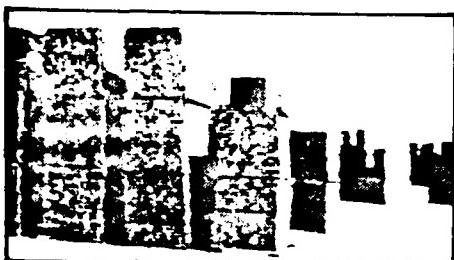
## HEAVY DUTY MATERIALS AND EQUIPMENT FOR COVERING AND BURYING



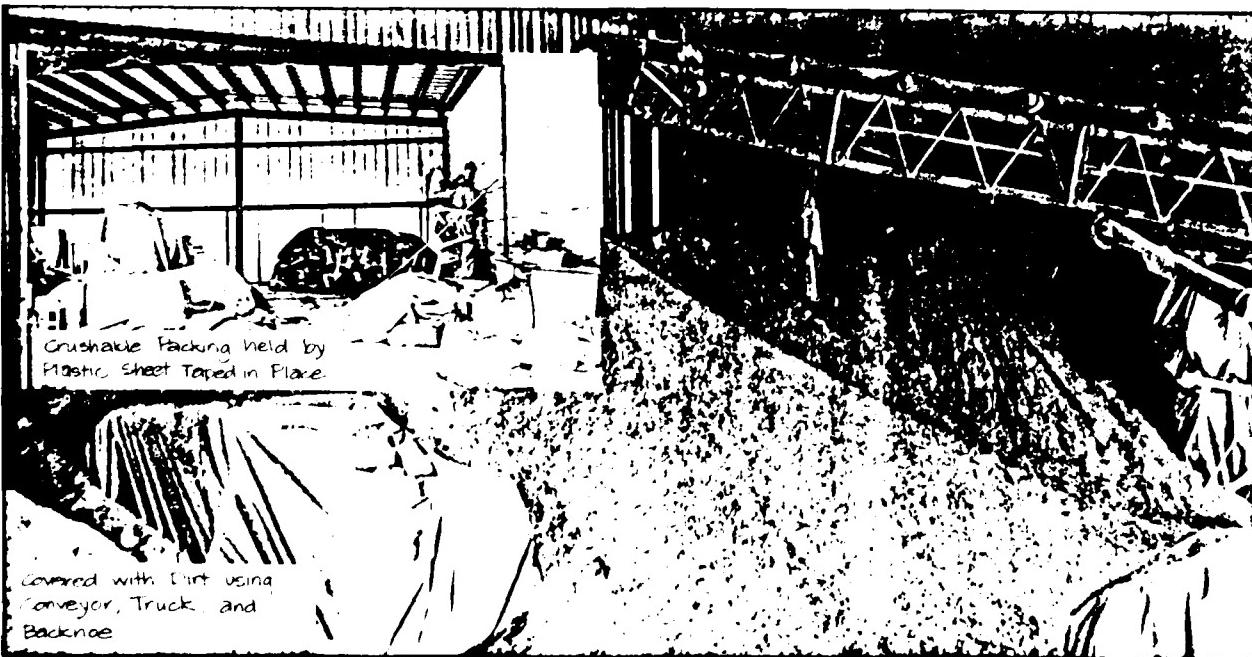
BULLDOZER



PRECAST CONCRETE SLABS AND COLUMNS ; END LOADER



LUMBER STACKS



### MATERIALS

DIRT  
SAND  
GRAVEL  
PLYWOOD  
LUMBER

CONCRETE SLABS  
CONCRETE PIERS  
METAL PLATES  
BRICK  
CONCRETE BLOCK

COAL  
RUBBLE  
CHAIN LINK FENCE  
SAND BAGS  
CEMENT SACKS

### EQUIPMENT

BULLDOZER  
END LOADER  
SNOW PLOW  
GRADER  
TRACTOR

CONVEYOR  
FORK LIFT  
WITH DEBRIS BOX  
DUMPSTER

RESOURCE INVENTORY SHEET

**HEAVY DUTY MATERIALS & EQUIPMENT FOR COVERING & BURYING TEAM #**

**AREA** \_\_\_\_\_ **CODE (IF USED)** \_\_\_\_\_ **SHEET #** \_\_\_\_\_

**ITEM #**      **DESCRIPTION & LOCATION**      **QUANTITY**

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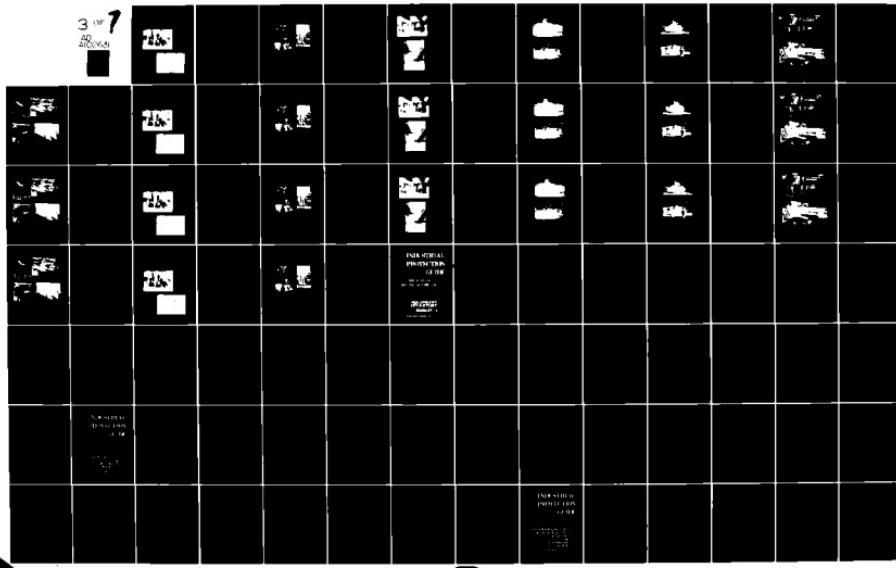
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INDUSTRIAL PROTECTION MANUAL.(U)

F/6 15/3

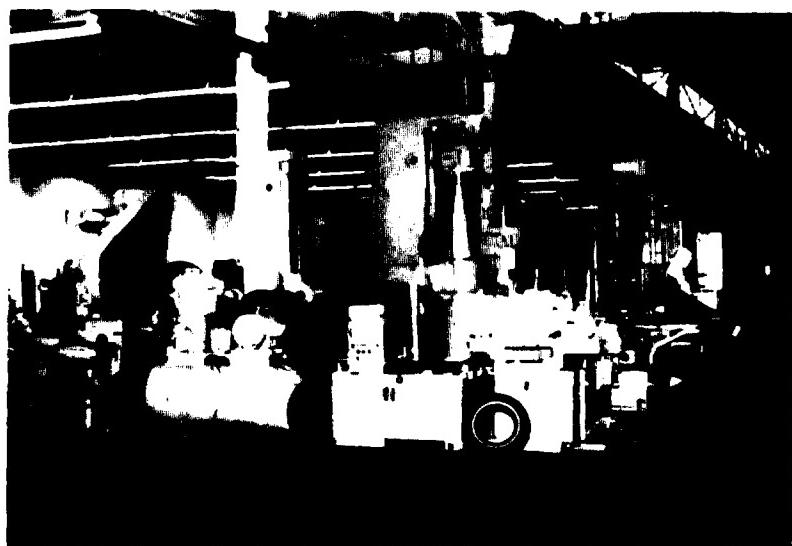
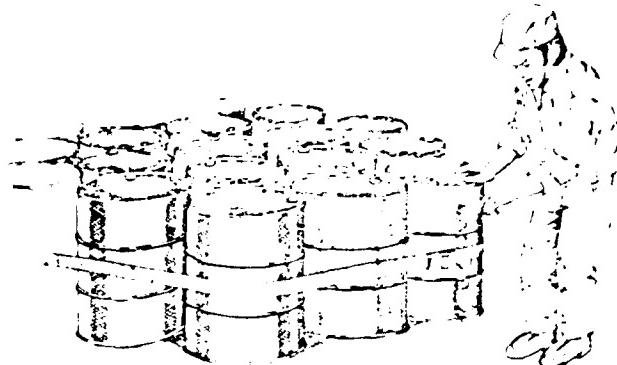
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UNCLASSIFIED SSI-8011

EMW-C-0154

NL



FOR FASTENING AND ANCHORING

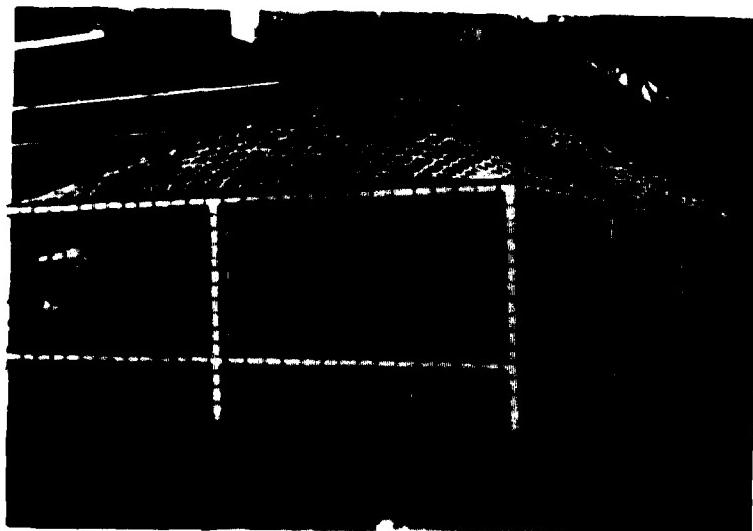


Fastening Materials

wire  
cable  
truckee strapping  
webbing  
reinforcing wire  
beams and channel  
welding rod  
chain link fence  
cable clamps  
turnbuckle

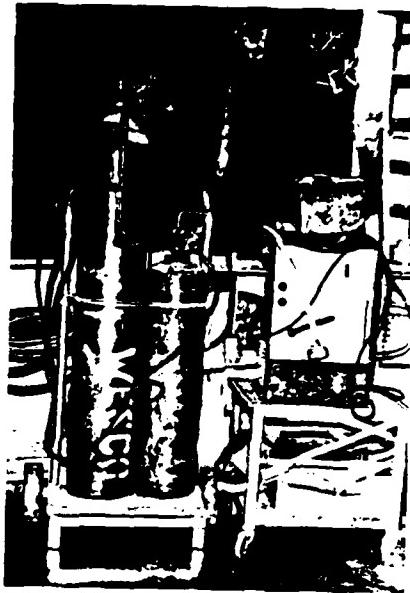
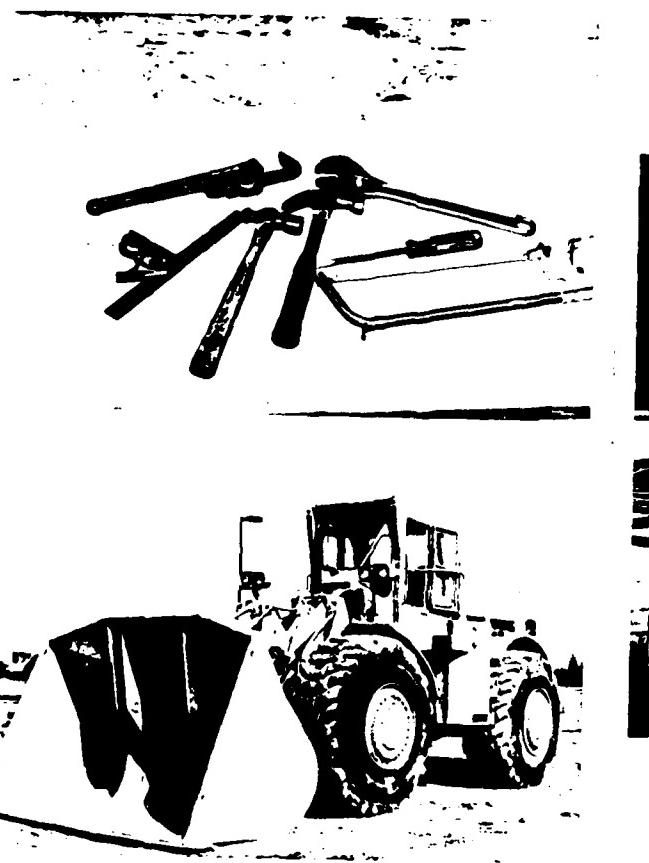
Anchors

pipe  
angle iron  
rebar  
light standards  
telephone poles  
concrete blocks





## RECOVERY



### Lifting & Moving Equipment

A-frame  
backhoe  
end loader  
winch  
tractor  
truck  
bulldozer

### Maintenance & Repair

welder  
torch  
hand torch  
machine tools  
hand tools  
equipment manual  
repair manual  
grinder  
generator

### Safety

radiac equipment  
disposable work clothes  
mobile pump units  
water tankers  
ditching equipment

**RESOURCE INVENTORY SHEET**

**RECOVERY**

**TEAM #** \_\_\_\_\_

**AREA** \_\_\_\_\_ **CODE (IF USED)** \_\_\_\_\_ **SHEET #** \_\_\_\_\_

<b>ITEM #</b>	<b>DESCRIPTION &amp; LOCATION</b>	<b>QUANTITY</b>
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FOR LIFTING, MOVING, TRANSPORTATION



Highway

stake truck  
flat bed  
U-haul trailer  
van  
tanker  
dump truck  
cement truck  
dumpster

Rail

flatcar  
boxcar  
hopper car  
tank car

Waterways

barge  
garbage scow  
raft  
ferry



In Plant

crane  
gantry  
forklift  
endloader  
cherry picker  
jacks  
bridge crane  
rollers

RESOURCE INVENTORY SHEET

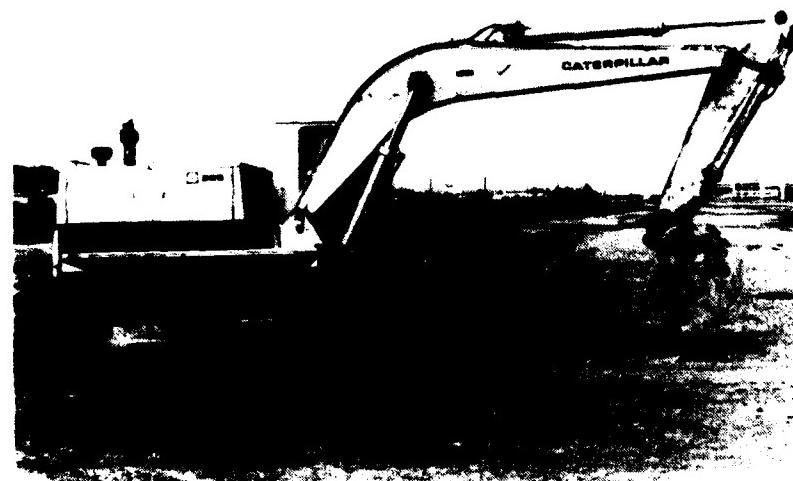
FOR LIFTING, MOVING, TRANSPORTING

TEAM # \_\_\_\_\_

AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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SHELTER CONSTRUCTION/UPGRADING



Equipment

shovel  
conveyor  
wheelbarrow  
endloader  
grader  
backhoe  
tractor  
picks  
saws

Materials

nails  
plywood  
lumber  
railway ties  
pipe  
concrete block  
precast concrete

RESOURCE INVENTORY SHEET

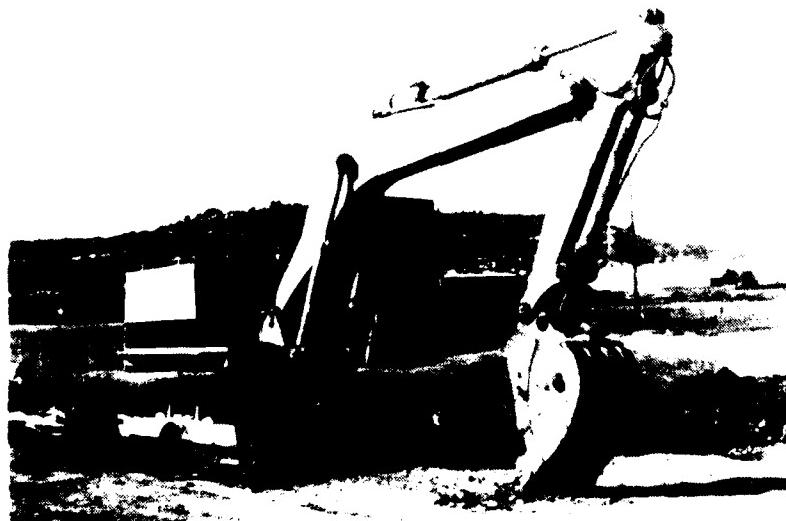
**SHELTER CONSTRUCTION/UPGRADING**

TEAM #   

AREA    CODE (IF USED)    SHEET #   

<u>ITEM #</u>	<u>DESCRIPTION &amp; LOCATION</u>	<u>QUANTITY</u>
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DITCHING & REMING



Equipment

grader  
end loader  
ditch diggers  
scrapers  
trucks  
backhoe  
tractors

RESOURCE INVENTORY SHEET

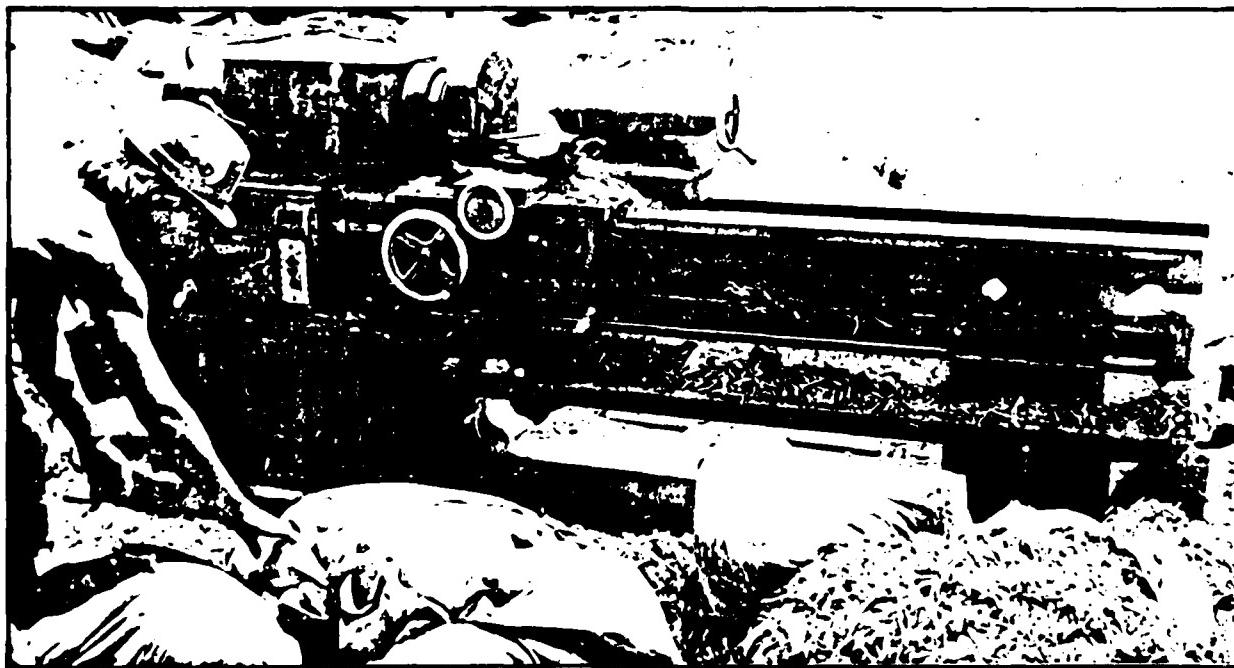
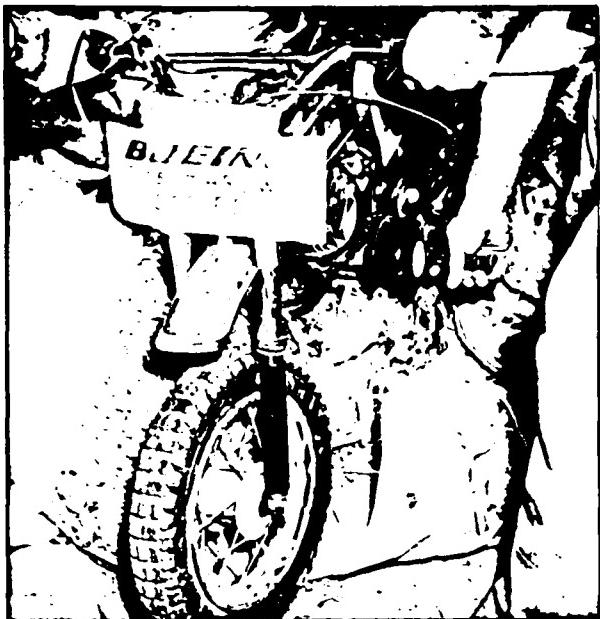
DITCHING & BERMING EQUIPMENT

TEAM # \_\_\_\_\_

AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_

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CRUSHABLE PACKING MATERIAL AND LIGHT COVERING MATERIAL



- CRUSHABLE PACKING -

HAY  
STRAW  
EXCELSOR  
METAL SHAVINGS  
WOOD CHIPS

PAPER  
CARDBOARD  
STYROFORM  
FIBERGLAS BATT'S  
PERLITE

- LIGHT COVERING -

MICA  
MINERAL WOOD  
CORK BOARD  
GRAIN  
SAWDUST  
TIRES

TAR PAPER  
RUGS  
SHEETS  
PLASTIC FILM

NEWSPRINT  
LINOLEUM  
CANVAS  
RUBBER SHEETING

RESOURCE INVENTORY SHEET

**CRUSHABLE MATERIALS & LIGHT COVERING MATERIAL**

TEAM #   

AREA                          CODE (IF USED)                          SHEET #             

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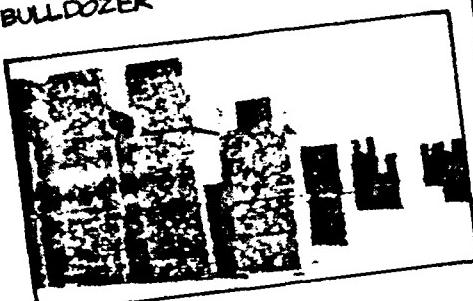
HEAVY DUTY MATERIALS AND EQUIPMENT FOR COVERING AND BURYING



BULLDOZER



PRECAST CONCRETE SLABS AND COLUMNS ; END LOADER



LUMBER STACKS



MATERIALS

DIRT  
SAND  
GRAVEL  
PLYWOOD  
LUMBER

CONCRETE SLABS  
CONCRETE PIERS  
METAL PLATES  
BRICK  
CONCRETE BLOCK

COAL  
RUBBLE  
CHAIN LINK FENCE  
SAND BAGS  
CEMENT SACKS

EQUIPMENT

BULLDOZER	CONVEYOR
END LOADER	FORK LIFT
SNOW PLOW	WITH DEBRIS BOX
GRADER	
TRACTOR	DUMPSTER

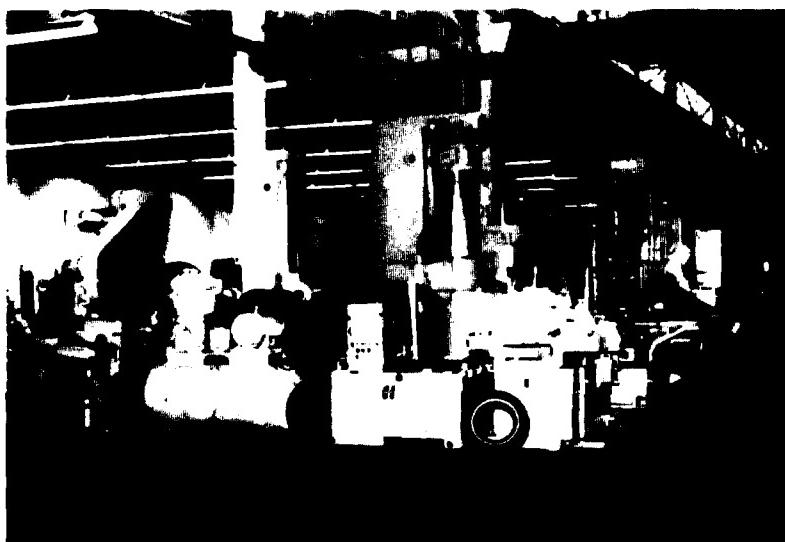
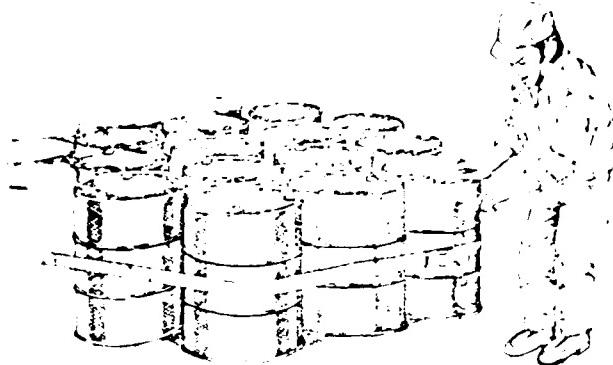
RESOURCE INVENTORY SHEET

**HEAVY DUTY MATERIALS & EQUIPMENT FOR COVERING & BURYING TEAM #**

**AREA** \_\_\_\_\_ **CODE (IF USED)** \_\_\_\_\_ **SHEET #** \_\_\_\_\_

<b>ITEM #</b>	<b>DESCRIPTION &amp; LOCATION</b>	<b>QUANTITY</b>
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FOR FASTENING AND ANCHORING

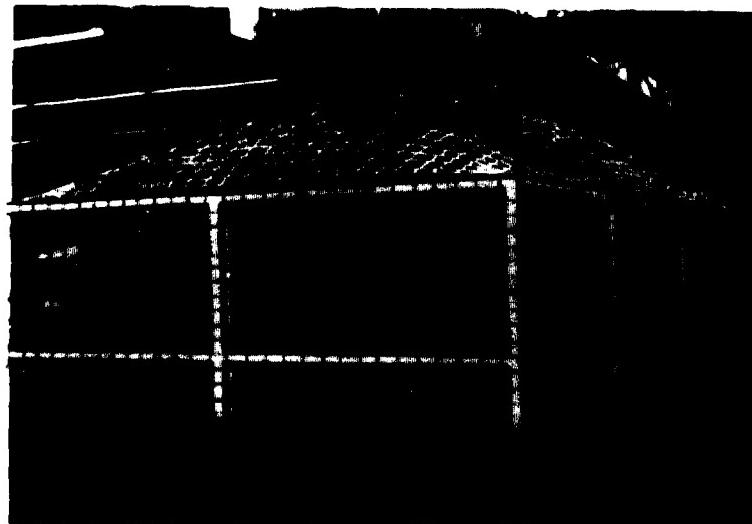


Fastening Materials

wire  
cable  
truckee strapping  
webbing  
reinforcing wire  
beams and channel  
welding rod  
chain link fence  
cable clamps  
turnbuckle

Anchors

pipe  
angle iron  
rebar  
light standards  
telephone poles  
concrete blocks



RESOURCE INVENTORY SHEET

**PARTS & EQUIPMENT**

TEAM # \_\_\_\_\_

AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_

ITEM #      DESCRIPTION & LOCATION      QUANTITY

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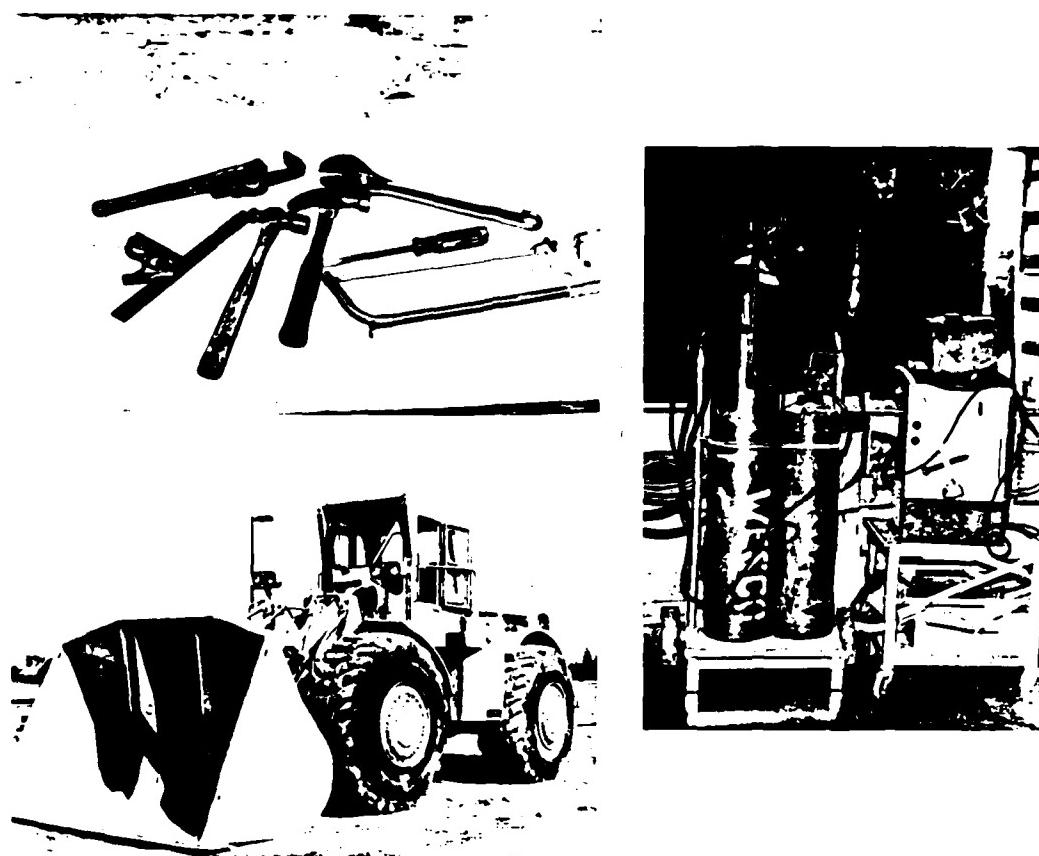
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## RECOVERY



### Lifting & Moving Equipment

A-frame  
backhoe  
end loader  
winch  
tractor  
truck  
bulldozer

### Maintenance & Repair

welder  
torch  
hand torch  
machine tools  
hand tools  
equipment manual  
repair manual  
grinder  
generator

### Safety

radiac equipment  
disposable work clothes  
mobile pump units  
water tankers  
ditching equipment

**RESOURCE INVENTORY SHEET**

**RECOVERY**

**TEAM #** \_\_\_\_\_

**AREA** \_\_\_\_\_ **CODE (IF USED)** \_\_\_\_\_ **SHEET #** \_\_\_\_\_

**ITEM #**      **DESCRIPTION & LOCATION**      **QUANTITY**

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FOR LIFTING, MOVING, TRANSPORTATION



Highway

stake truck  
flat bed  
U-haul trailer  
van  
tanker  
dump truck  
cement truck  
dumpster

Rail

flatcar  
boxcar  
hopper car  
tank car

Waterways

barge  
garbage scow  
raft  
ferry



In Plant

crane  
gantry  
forklift  
endloader  
cherry picker  
jacks  
bridge crane  
rollers

RESOURCE INVENTORY SHEET

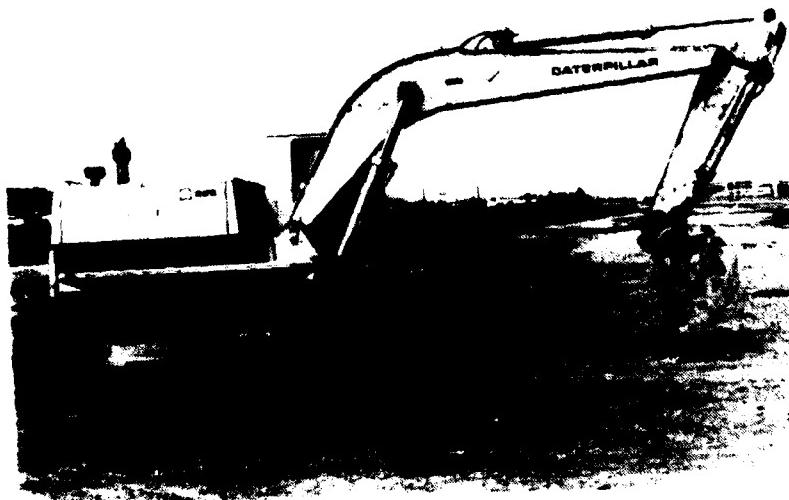
FOR LIFTING, MOVING, TRANSPORTING

TEAM # \_\_\_\_\_

AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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SHELTER CONSTRUCTION/UPGRADING



Equipment

shovel  
conveyor  
wheelbarrow  
endloader  
grader  
backhoe  
tractor  
picks  
saws

Materials

hammer  
sledge  
axe  
generator  
batteries  
pumps  
blower  
A-frames  
winches  
nails  
plywood  
lumber  
railway ties  
pipe  
concrete block  
precast concrete

**RESOURCE INVENTORY SHEET**

**SHELTER CONSTRUCTION/UPGRADING**

TEAM # \_\_\_\_\_

AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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DITCHING & BERMING



Equipment

- grader
- end loader
- ditch diggers
- scraper
- truck
- backhoe
- tractor

RESOURCE INVENTORY SHEET

DITCHING & BERMING EQUIPMENT

TEAM # \_\_\_\_\_

AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_

ITEM #      DESCRIPTION & LOCATION      QUANTITY

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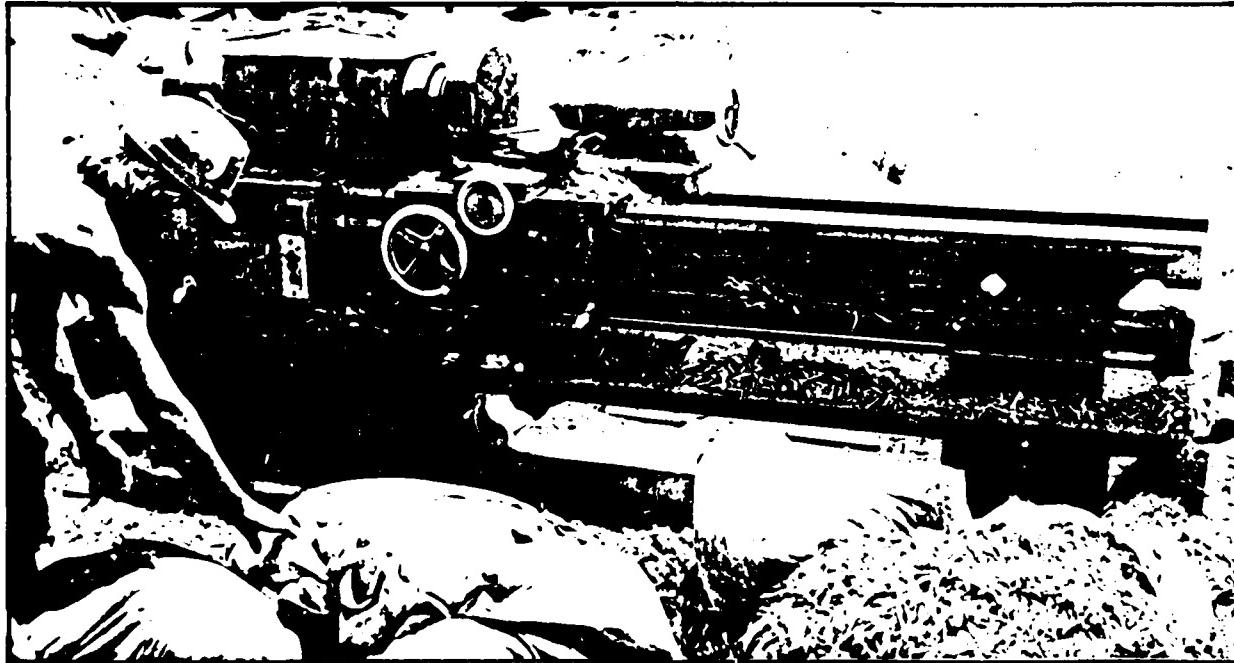
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CRUSHABLE PACKING MATERIAL AND LIGHT COVERING MATERIAL



-CRUSHABLE PACKING-

HAY	PAPER
STRAW	CARDBOARD
EXCELSOR	STYROFORM
METAL SHAVINGS	FIBERGLAS BATT'S
WOOD CHIPS	PERLITE

-LIGHT COVERING-

MICA	TAR PAPER	NEWSPRINT
MINERAL WOOD	RUGS	LINOLEUM
CORK BOARD	SHEETS	CANVAS
GRAIN	PLASTIC FILM	RUBBER SHEETING
SAWDUST		
TIRE'S		

RESOURCE INVENTORY SHEET

**CRUSHABLE MATERIALS & LIGHT COVERING MATERIAL**

TEAM # \_\_\_\_\_

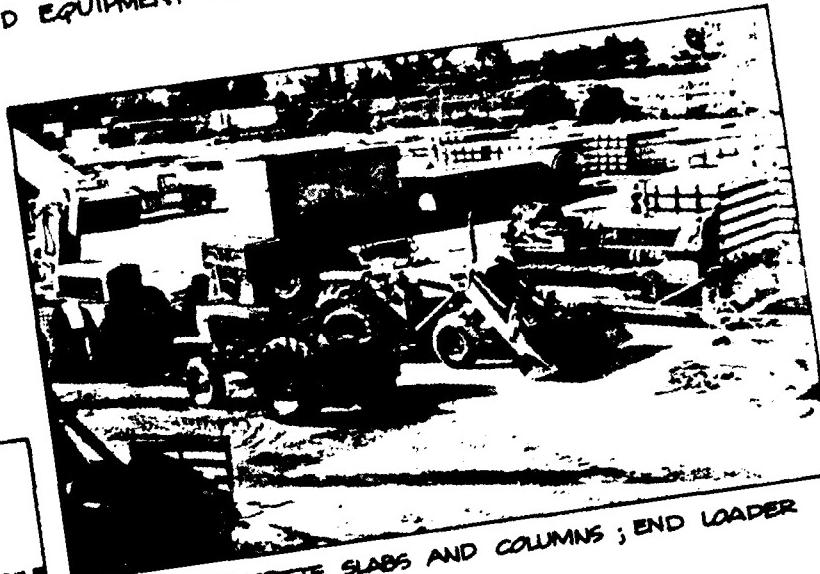
AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_

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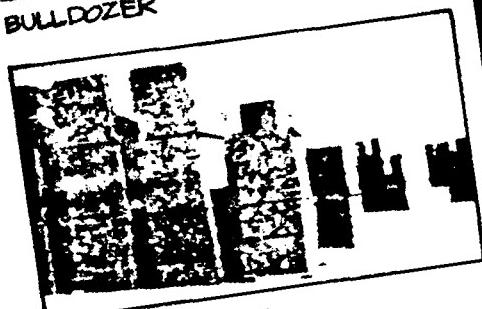
HEAVY DUTY MATERIALS AND EQUIPMENT FOR COVERING AND BURYING



BULLDOZER



PRECAST CONCRETE SLABS AND COLUMNS ; END LOADER



LUMBER STACKS



MATERIALS

- DIRT
- SAND
- GRAVEL
- PLYWOOD
- LUMBER
- CONCRETE SLABS
- CONCRETE PIERS
- METAL PLATES
- BRICK
- CONCRETE BLOCK

- COAL
- RUBBLE
- CHAIN LINK FENCE
- SAND BAGS
- CEMENT SACKS

EQUIPMENT

- BULLDOZER
- END LOADER
- SNOW PLOW
- GRADER
- TRACTOR
- CONVEYOR
- FORK LIFT
- WITH DEBRIS BOX
- DUMPSTER

RESOURCE INVENTORY SHEET

**HEAVY DUTY MATERIALS & EQUIPMENT FOR COVERING & BURYING TEAM #** \_\_\_\_\_

AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_

**ITEM #**      **DESCRIPTION & LOCATION**      **QUANTITY**

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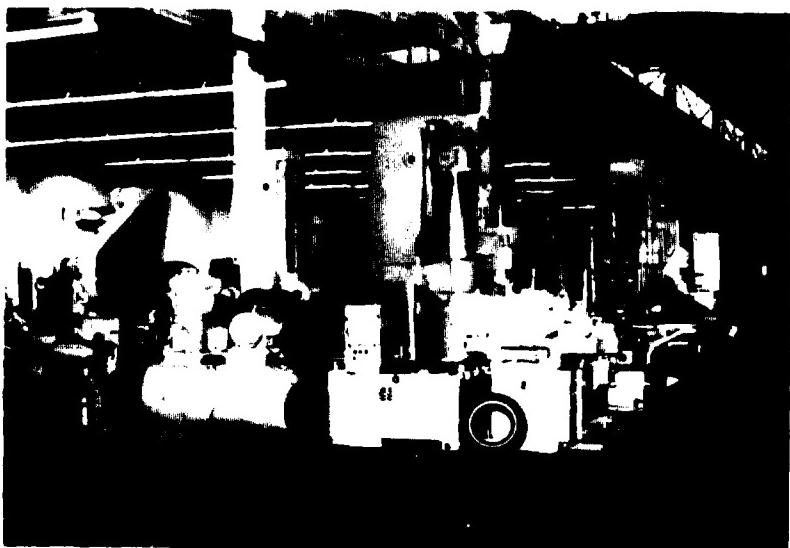
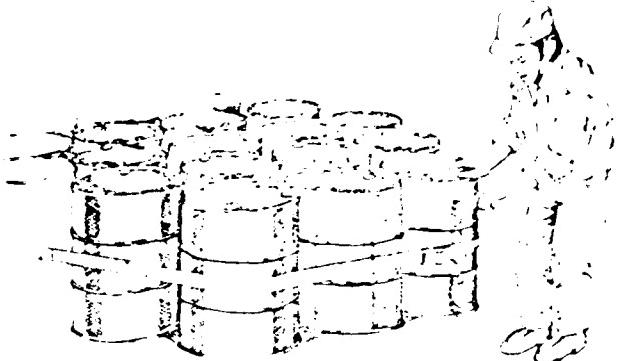
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FOR FASTENING AND ANCHORING

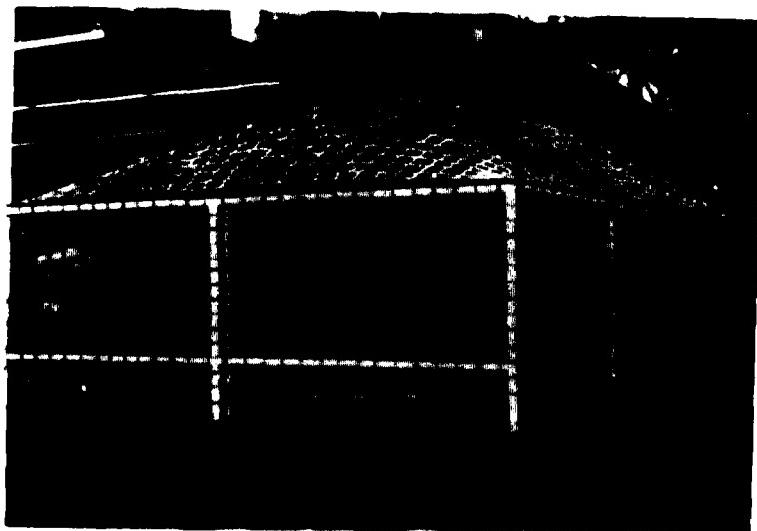


Fastening Materials

wire  
cable  
trucker strapping  
webbing  
reinforcing wire  
beams and channel  
welding rod  
chain link fence  
cable clamps  
turnbuckle

Anchors

pipe  
angle iron  
rebar  
light standards  
telephone poles  
concrete blocks



**RESOURCE INVENTORY SHEET**

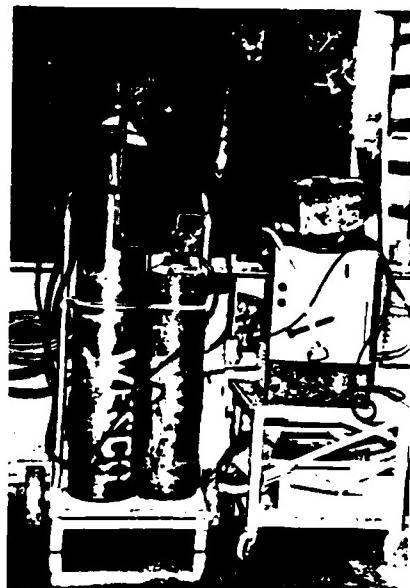
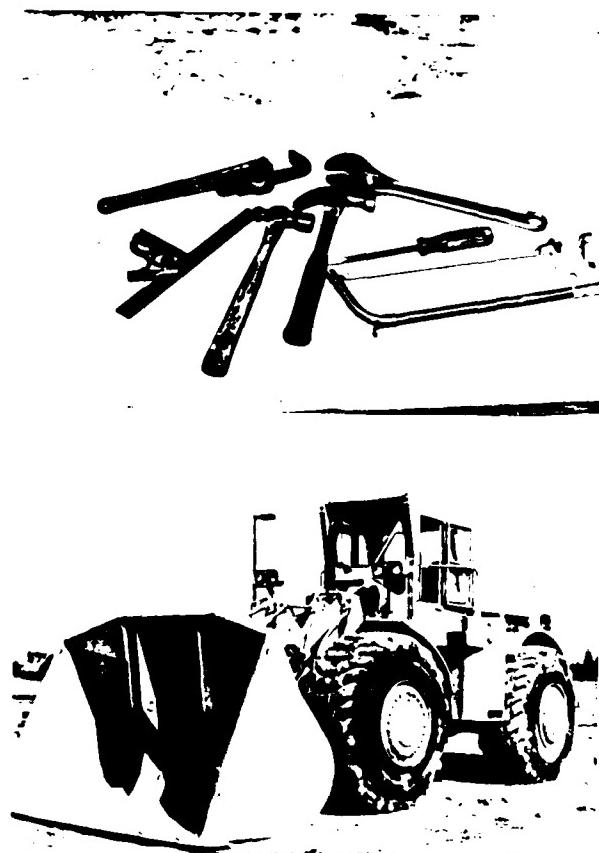
**FASTENING & ANCHORING**

TEAM #   

AREA    CODE (IF USED)    SHEET #   

<u>ITEM #</u>	<u>DESCRIPTION &amp; LOCATION</u>	<u>QUANTITY</u>
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## RECOVERY



### Lifting & Moving Equipment

A-frame  
backhoe  
end loader  
winch  
tractor  
truck  
bulldozer

### Maintenance & Repair

welder  
torch  
hand torch  
machine tools  
hand tools  
equipment manual  
repair manual  
grinder  
generator

### Safety

radiac equipment  
disposable work clothes  
mobile pump units  
water tankers  
ditching equipment

**RESOURCE INVENTORY SHEET**

**RECOVERY**

**TEAM #** \_\_\_\_\_

**AREA** \_\_\_\_\_ **CODE (IF USED)** \_\_\_\_\_ **SHEET #** \_\_\_\_\_

**ITEM #**      **DESCRIPTION & LOCATION**      **QUANTITY** \_\_\_\_\_

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FOR LIFTING, MOVING, TRANSPORTATION



Highway

stake truck  
flat bed  
U-haul trailer  
van  
tanker  
dump truck  
cement truck  
dumpster

Rail

flatcar  
boxcar  
hopper car  
tank car

Waterways

large  
garbage scow  
raft  
ferry



In Plant

crane  
gantry  
forklift  
endloader  
cherry picker  
jacks  
bridge crane  
rollers

RESOURCE INVENTORY SHEET

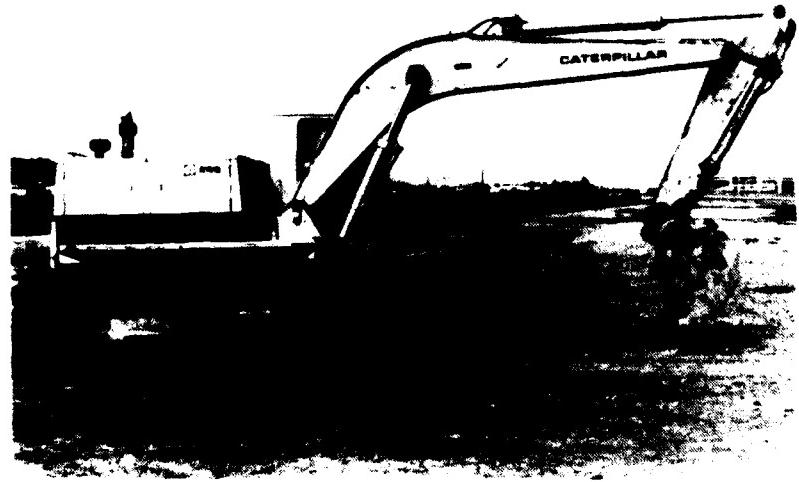
FOR LIFTING, MOVING, TRANSPORTING

TEAM # \_\_\_\_\_

AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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SHELTER CONSTRUCTION/UPGRADING



Equipment

shovel  
conveyor  
wheelbarrow  
endloader  
**grader**  
backhoe  
**tractor**  
picks  
saws

Materials

nails  
plywood  
lumber  
railway ties  
pipe  
concrete block  
precast concrete  
A-frames  
winches

**RESOURCE INVENTORY SHEET**

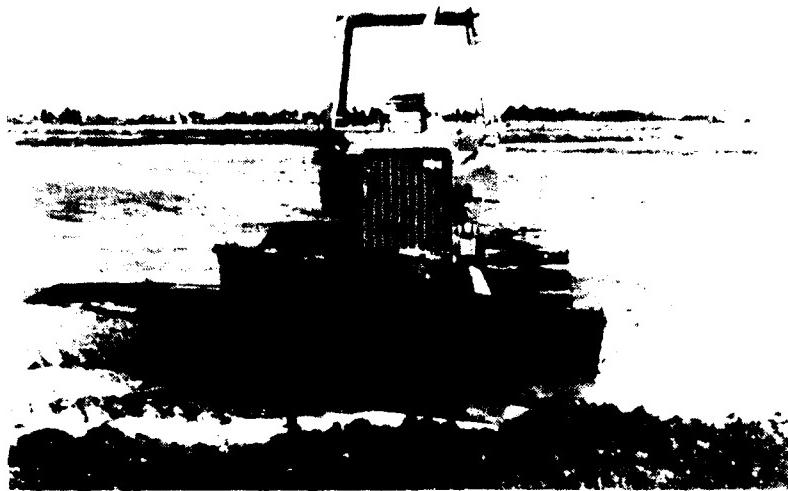
**SHELTER CONSTRUCTION/UPGRADING**

**TEAM #** \_\_\_\_\_

**AREA** \_\_\_\_\_ **CODE (IF USED)** \_\_\_\_\_ **SHEET #** \_\_\_\_\_

<b>ITEM #</b>	<b>DESCRIPTION &amp; LOCATION</b>	<b>QUANTITY</b>
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DITCHING & BERMING



Equipment  
grader  
end loader  
ditch diggers  
scrapers  
trucks  
backhoes  
tractors

RESOURCE INVENTORY SHEET

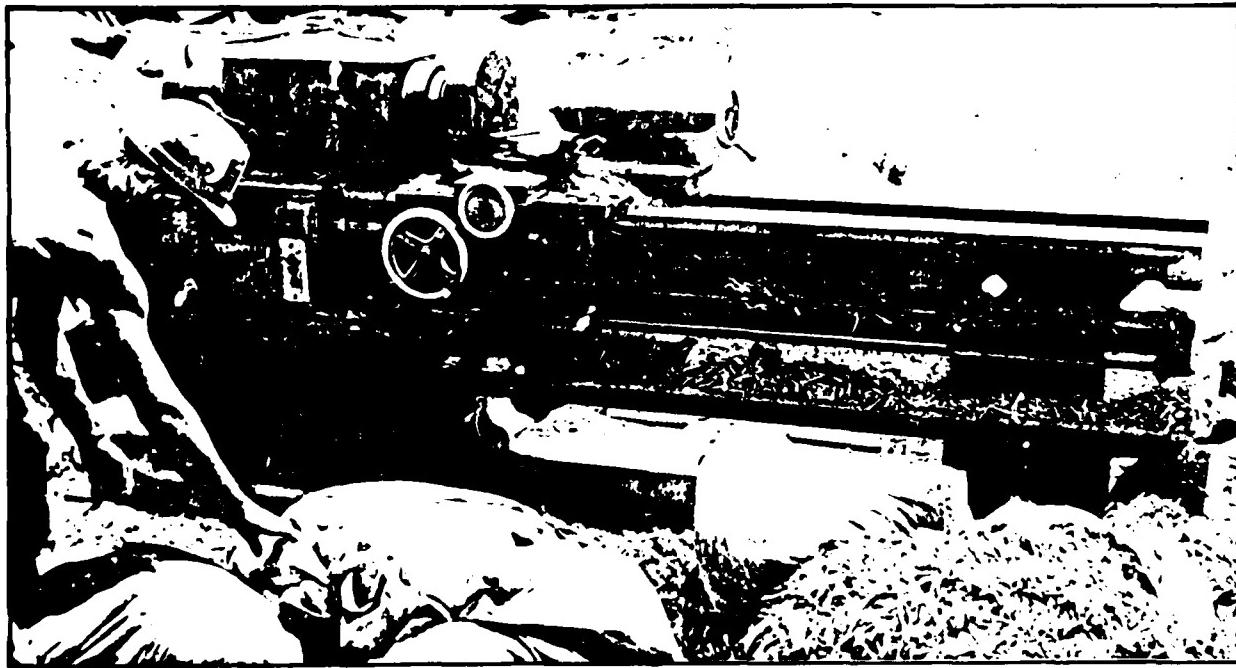
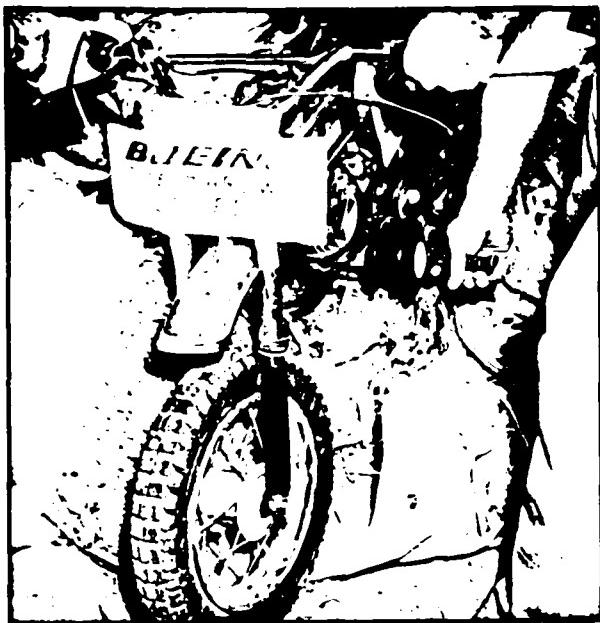
DITCHING & BERMING EQUIPMENT

TEAM # \_\_\_\_\_

AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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CRUSHABLE PACKING MATERIAL AND LIGHT COVERING MATERIAL



- CRUSHABLE PACKING -

HAY	PAPER
STRAW	CARDBOARD
EXCELSIOR	STYROFORM
METAL SHAVINGS	FIBERGLAS BATT'S
WOOD CHIPS	PERLITE

- LIGHT COVERING -

MICA	TAR PAPER	NEWSPRINT
MINERAL WOOD	RUGS	LINOLEUM
CORK BOARD	SHEETS	CANVAS
GRAIN	PLASTIC FILM	RUBBER SHEETING
SAWDUST		
TIRE'S		

RESOURCE INVENTORY SHEET

**CRUSHABLE MATERIALS & LIGHT COVERING MATERIAL**

TEAM #   

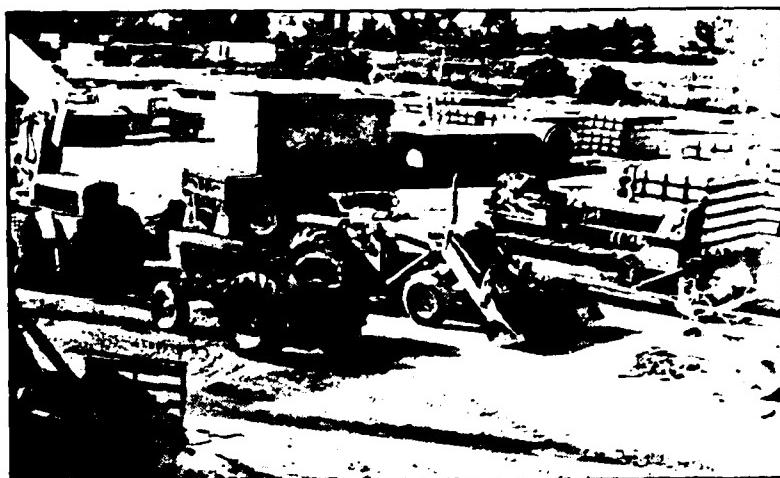
AREA                          CODE (IF USED)                          SHEET #             

<u>ITEM #</u>	<u>DESCRIPTION &amp; LOCATION</u>	<u>QUANTITY</u>
1		
2		
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## HEAVY DUTY MATERIALS AND EQUIPMENT FOR COVERING AND BURYING



BULLDOZER



PRECAST CONCRETE SLABS AND COLUMNS ; END LOADER



LUMBER STACKS



### MATERIALS

DIRT  
SAND  
GRAVEL  
PLYWOOD  
LUMBER

CONCRETE SLABS  
CONCRETE PIERS  
METAL PLATES  
BRICK  
CONCRETE BLOCK

COAL  
RUBBLE  
CHAIN LINK FENCE  
SAND BAGS  
CEMENT SACKS

### EQUIPMENT

BULLDOZER  
END LOADER  
SNOW PLOW  
GRADER  
TRACTOR

CONVEYOR  
FORK LIFT  
WITH DEBRIS BOX  
DUMPSTER

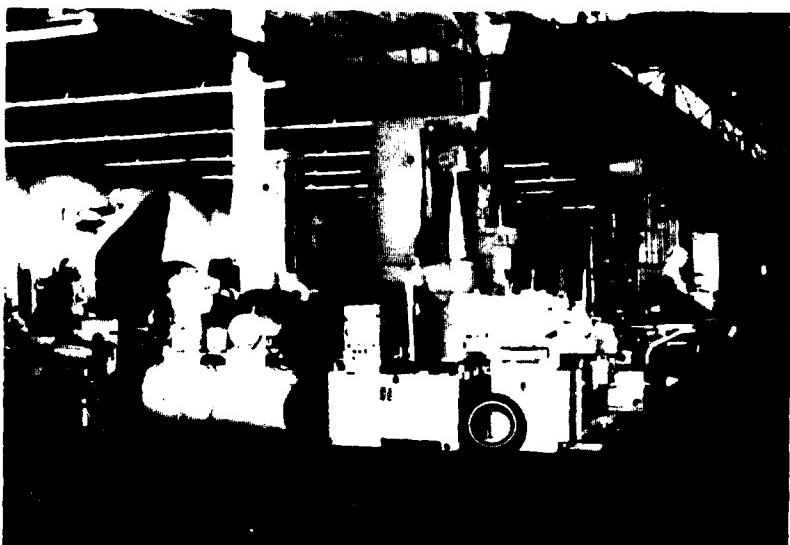
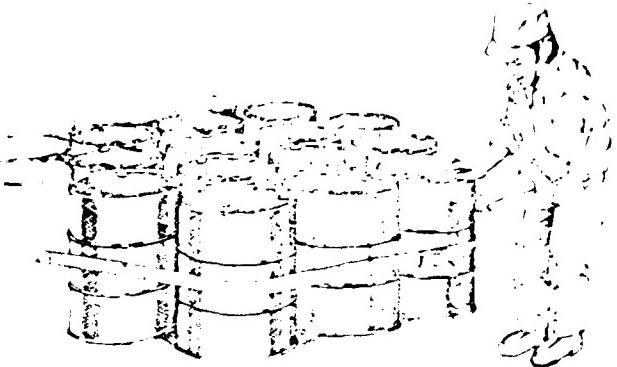
RESOURCE INVENTORY SHEET

**HEAVY DUTY MATERIALS & EQUIPMENT FOR COVERING & BURYING TEAM #**

AREA \_\_\_\_\_ CODE (IF USED) \_\_\_\_\_ SHEET # \_\_\_\_\_

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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FOR FASTENING AND ANCHORING

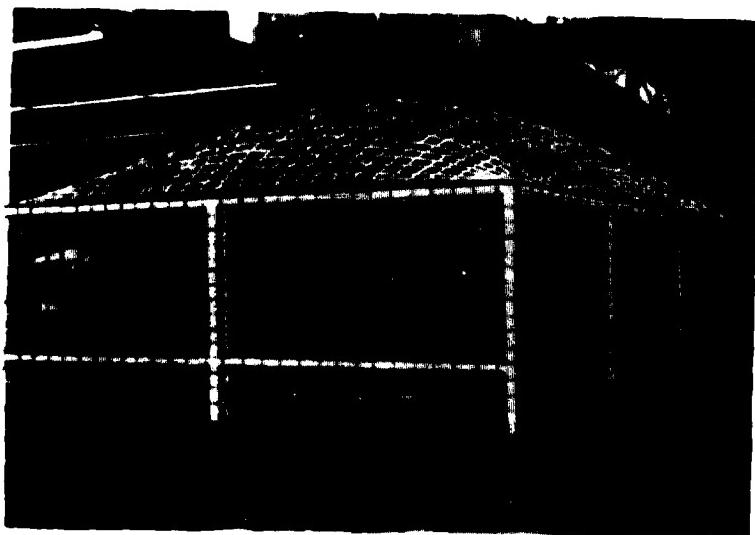


Fastening Materials

wire  
cable  
trucker strapping  
webbing  
reinforcing wire  
beams and channel  
welding rod  
chain link fence  
cable clamps  
turnbuckle

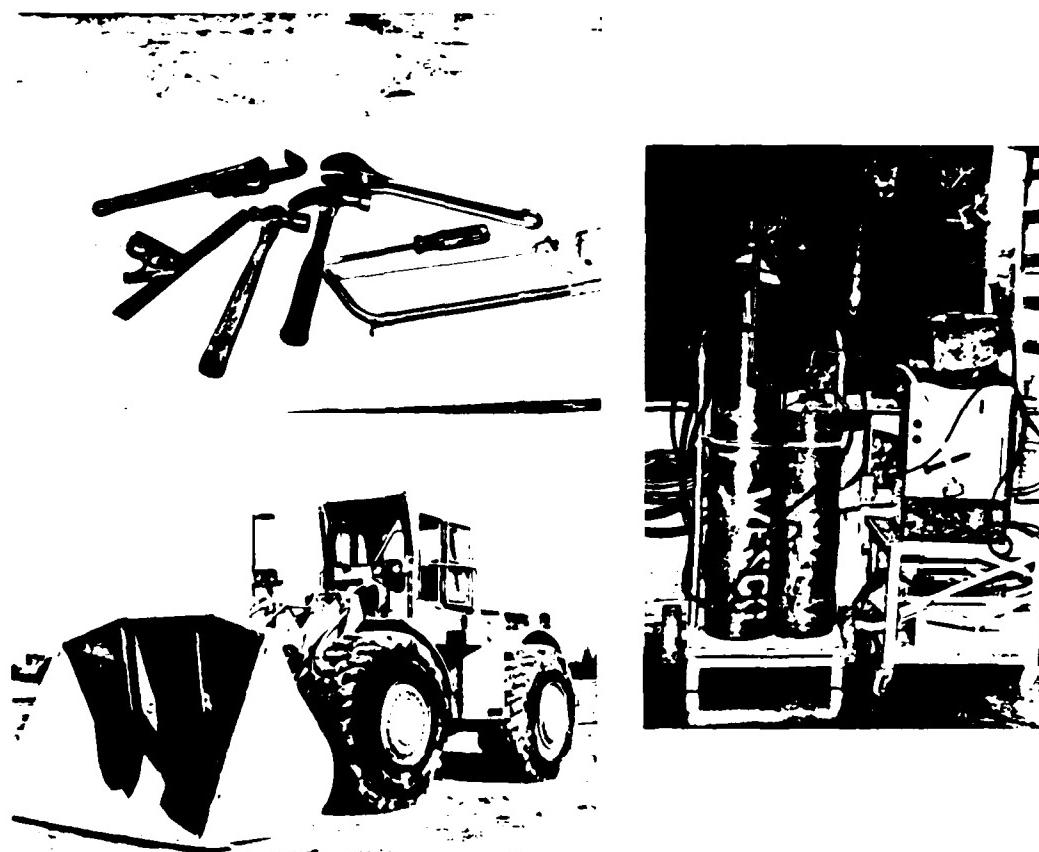
Anchors

pipe  
angle iron  
rebar  
light standards  
telephone poles  
concrete blocks





## RECOVERY



### Lifting & Moving Equipment

A-frame  
backhoe  
end loader  
winch  
tractor  
truck  
bulldozer

### Maintenance & Repair

welder  
torch  
hand torch  
machine tools  
hand tools  
equipment manual  
repair manual  
grinder  
generator

### Safety

radiac equipment  
disposable work clothes  
mobile pump units  
water tankers  
ditching equipment

**RESOURCE INVENTORY SHEET**

**RECOVERY**

**TEAM #** \_\_\_\_\_

**AREA** \_\_\_\_\_ **CODE (IF USED)** \_\_\_\_\_ **SHEET #** \_\_\_\_\_

**ITEM #**      **DESCRIPTION & LOCATION**      **QUANTITY**

**1** \_\_\_\_\_

**2** \_\_\_\_\_

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**14** \_\_\_\_\_

# **INDUSTRIAL**

# **PROTECTION**

# **GUIDE**

**CRISIS RELOCATION**  
**INDUSTRIAL HARDENING PLAN**

**EQUIPMENT  
INVENTORY**  
**BOOKLET 6**

**CONTINUITY SERVICE, INC.**

**CRISIS RELOCATION INDUSTRIAL HARDENING PLAN**

**Booklet 6**

**EQUIPMENT INVENTORY**

This is one of ten booklets of the Industrial Hardening Manual  
developed for the  
Federal Emergency Management Agency  
under Contract No. EMW-C-0154, Work Unit 1124E

**SCIENTIFIC SERVICE, Inc.**  
Redwood City, California 94063

Booklet 6  
**EQUIPMENT INVENTORY**

**Coordinator:** \_\_\_\_\_

(name)

**Alternate:** \_\_\_\_\_

(name)

**Objective:** To arrive at an equipment list that is rated according to each item's relative importance to production, so that a decision can be made as to whether to protect it very well, scarcely at all, move it, etc.

This booklet is part of a plan to protect industrial plant equipment from possible damage in the event of a major disaster. It will enable you to develop a list of plant equipment organized to establish hardening priorities. There may be a limit to the plant equipment that you will be able to protect with the time, materials, equipment, and personnel available, so you may have to make some hard choices. There are a number of approaches that can simplify this task. For example, suppose there is a great deal of duplication in production equipment and processes at your plant. If that is the case, you could start hardening just part of this equipment. For example, consider a single shift production line including 1 lathe, 4 punch presses, 6 drill presses, and 2 riveting machines. You could immediately evacuate or harden the lathe and one combination of 2 punch presses, 3 drill presses, and 1 riveting machine -- then, if time and resources permit, harden the other (duplicate) set. If there is so little duplication (or you already operate three shifts) that this option is not really practical -- and you are faced with insufficient time, materials, or personnel to harden everything -- then you should consider alternative methods of production that require less equipment. You may be able to salvage enough equipment to return to this alternative production method with fewer production penalties. Should neither of these two approaches work, another method has been provided in Booklets 6 through 8.

When the inventory is completed, give the forms to the Hardening Operations Manager.

## **INSTRUCTIONS FOR COORDINATOR**

You will be assembling a crew to compile a complete list of plant equipment (see sample form at the beginning of the worksheets). This list will be used by the Hardening Operations Manager to decide priorities for protecting equipment according to methods identified in Booklet 9. After you examine this booklet and the inventory form, you should look at the hardening options in Booklet 9.

When your crew compiles the inventory, management will require additional information -- for example, mounting data, size, weight, and general mobility -- because equipment to be moved must be readily disconnected, manageable with onsite materials handling equipment, and sized to fit on trucks, barges, flatcars, trailers, etc., and/or wherever it is to go. Where equipment is duplicated, number the items in sequence during inventory from best to worst to show the order for hardening attention. (This may require your maintenance engineer to identify the best units to save.)

Read through booklet, then provide an estimate of your personnel needs to management so you can complete the task.

Organize your crew into teams so all plant areas can be covered, rapidly.

- o Use one or two men to a team.
- o Assign specific areas of the plant to each survey team.

Example — Team 1: Outside areas.

Team 2: Bays 1 and 2 of building A.

Team 3: First through 4th floors of  
building B.

Team 4: Process line No. 4.

Reproduce and distribute inventory books to each team (make certain that enough forms are available).

If you have waited until the evacuation order, arrange to have completed inventory sheets returned to you (in exchange for another blank) as each sheet is finished. (Use second member of team, or establish a special messenger squad to circulate and exchange blank forms for completed ones.) To expedite the next stage, give completed forms to the Hardening Operations Manager as they are collected.

It may be faster to use existing knowledge or records of equipment (i.e., inventory data, or plant layout drawings) where readily available, and have teams recheck data by actual inspection as they enter additional information required.

## SCHEDULE

<b>Tasks</b>	<b>Time Line</b> (elapsed)
Organize teams (1 to 2 men maximum)	0 to 15 min
Pass out inventory sheets	
Review the instructions (starting on page 5) with team members.	
<b>Team Members:</b>	
Fill out inventory sheets provided each team	15 min to 1 hr
Return sheets to Coordinator.	
<b>Coordinator:</b>	
Review team progress and reassign areas as required	20 min to 1 hr
Review inventory sheets, revise and correct as required.	
Release team members to labor pool to be reassigned.	1 hr
Turn in inventory sheets to Vulnerability and Priority Rating team (Booklet 7 Coordinator) as the sheets are completed	20 min to 1 hr

## **INSTRUCTIONS FOR TEAM MEMBERS**

Instructions on how to fill out equipment inventory sheets are as follows  
(see example sheet at the beginning of the worksheets):

STEP 1: Enter general location of equipment and page number at the top of each page, identify team.

STEP 2: Itemize equipment\* name and description (quantity, size).

**DO --** o Provide a complete list of plant equipment (fixed, installed, movable or mobile)

o List identical equipment as one line item where possible  
Example: Drill presses (6 standing, 4 bench)

o Then tag each with a number to show the next crew which unit to save first (best remaining unit until time or resources run out)

o Provide approximate width, depth, height and weight data on all equipment essential to production.

\* The final objective is to arrive at an equipment list that is rated according to each item's relative importance to production, so that a decision can be made as to whether to protect it very well, scarcely at all, move it, etc.

**DON'T** -- o Do not list parts of a single piece of equipment as separate items unless they are mounted separately.

Example: Do not list "electric motor mounted on drill press"; just list drill press.

o Do not list process line equipment as a single item.

Example: Do not list "tomato press line"; instead, break down into operational components so relative importance of items in the line will be determined.

**STEP 3:** Under "Remarks" list:

- o Mounting information: Not secured; bolted to concrete floor, wall; number and size of bolts, time to remove them; hard-wired (H) or quick-disconnect (Q.D.) power input.
- o Indicate whether it is (U) unmovable<sup>1</sup>, (M) movable<sup>2</sup>, (D) difficult to move<sup>3</sup>.

**STEP 4:** List under "SD Time" how long it will take to shut down that equipment, if operating.

- o If already shut down, enter "O";
- o If management indicates the equipment is to continue operating throughout the crisis period, enter an "X" in "SD time".

1. Requires outside mover and equipment, or cannot be moved at all.  
2. Easily moved in minutes to one hour without tieing up major materials handling equipment.  
3. Movable in a period of several hours, tieing up or taxing available cranes, etc.

STEP 5: Establish and record the essential rating of the equipment. Record one of the following Ratings in the "E" column of the inventory form.

<b>"E" Rating</b>	<b>Description</b>
1	<b>Absolutely Essential</b> --- Equipment <u>required to operate</u> during the crisis period to ensure survival supplies for the population. If more than one unit, harden half of units and operate the other half through crisis. If only one unit, shut down and harden, so it will be available post-crisis. (If it is important to survival during the crisis, it should be more important to survival after it.)
2	<b>Essential to the Process</b> --- Equipment that is a key to some step in the production process which would stop all regular production immediately if it were eliminated, but would not make it impossible to jury rig an alternative process with lower output. (One of a kind for current production level, but do-able via alternative process.)
3	<b>Essential for Normal Operations</b> --- Equipment that is required principally for normal operation of the plant, but for which there are several of a kind with production rate affected by numbers available.
4	<b>Non-Essential</b> --- Safety and pollution equipment, and backup equipment used only for occasional peak demand periods.

STEP 6: Establish and record an equipment replacement/repair rating. This rating is not for normal operational repair, but rather repair after something like an earthquake overturning the piece of equipment or the building falling on it. Record one of the following replacement/repair ratings in the "RR" column of the inventory form.

<b>"RR" Rating</b>	<b>Description</b>
1	<b>Impossible</b> --- refers to those items not repairable without new parts from outside, and outside help.
2	<b>Difficult</b> --- includes those items that would be better sent outside for repair or replacement work, but might be replaced or repaired with some difficulty by inplant personnel using materials and equipment on hand.
3	<b>Possible</b> --- includes those items that could be repaired by inhouse personnel without too much difficulty using materials and equipment on hand.
4	<b>Easy</b> --- refers to items for which many spares or substitute parts are commonly available both onsite and off and which can be repaired with resources on hand, or by simply jury rigging common materials.

Essential ratings and Replacement/Repair ratings are summarized on the back of the page facing the worksheets.

W O R K S H E E T S

## ESSENTIAL RATINGS

## REPLACEMENT/REPAIR RATINGS

<b>Rating</b>	<b>Description</b>	<b>Rating</b>	<b>Description</b>
1 <b>Absolutely Essential</b> ---	Equipment required to <u>operate</u> during the crisis period to ensure survival supplies for the population. If more than one unit, harden half of units and operate the other half through crisis. If only one unit, shut down and harden, so it will be available post-crisis. (If it is important to survival during the crisis, it should be more important to survival after it.)	1 <b>Impossible</b> --- refers to those items not repairable without new parts from outside, and outside help.	
2 <b>Essential to the Process</b> ---	Equipment that is a key to some step in the production process which would stop all regular production immediately if it were eliminated, but would not make it impossible to jury rig an alternative process with lower output. (One of a kind for current production level, but do-able via alternative process.)	2 <b>Difficult</b> --- includes those items that would be better sent outside for repair or replacement work, but might be replaced or repaired with some difficulty by inplant personnel using materials and equipment on hand.	
3 <b>Essential for Normal Operations</b> ---	Equipment that is required principally for normal operation of the plant, but for which there are several of a kind with production rate affected by numbers available.	3 <b>Possible</b> --- includes those items that could be repaired by inhouse personnel without too much difficulty using materials and equipment on hand.	
4 <b>Non-Essential</b> ---	Safety and pollution equipment, and backup equipment used only for occasional peak demand periods.	4 <b>Easy</b> --- refers to items for which many spares or substitute parts are commonly available both onsite and off and which can be repaired with resources on hand, or by simply jury rigging common materials.	

Each inventory sheet should be used for one area only. If you start to inventory another area --- start another worksheet. Turn in sheets as they are completed to coordinator.

B  
FLIR 5

## EQUIPMENT INVENTORY WORKSHEET

ITEM #	EQUIPMENT NAME AND DESCRIPTION	QTY	SIZE	REMARKS	SQUAD MEMBERS		PAGE #
					NAME	TIME	
1	AIR COMPRESSORS # 1 AND # 2 160 CFM WATER-COOLED 125 HP 340 V	2	H 10 FT W 5 FT L 2 FT dia. dia.	ONE HORIZONTAL AND ONE VERTICAL CYLINDER IN L-SHAPE DESIGN 5/8" BOLTS TO FLOOR	J	2	1
2	AIR COMPRESSORS # 3, 4, AND 5 155 CFM 40 HP, 240 V WATER-COOLED	3	H 4 FT W 4 FT L 12 FT dia. dia.	HORIZONTAL SINGLE-STAGE HEAVY CASTINGS BOLTED TO CONCRETE PAD WITH 1/2" BOLTS NARROW BASE	O	3	2
3	AIR RECEIVER, PRESSURE TANK FOR PLANT AIR SUPPLY TWO 5" AIR LINES, 1/2" DRAIN TWO GAUGES	1	H 12 FT W 5 FT L 6 FT dia. dia.	ASME PRESSURE VESSEL WITH VERTICAL ORIENTATION BOLTED TO CONCRETE PAD WITH 4 1/2" BOLTS	O	3	3
4	MILLING MACHINE CINCINNATI MILACRON	1	H 6 FT W 4 FT L 6 FT dia. dia.	VERTICAL MILL HEAVY CASTINGS BOLTED TO CONCRETE FLOOR WITH 3/8" BOLTS	O	2	3
5	AIR HOIST, ASTON-TYPE WIRE ROPE EQUIPPED 4,000 LBS CAPACITY	12	H 3 FT W 16 IN. L 16 IN.	HUNG ON BRIDGE CRANE'S WITH ONE 3/8" BOLT	O	3	3
6	AIR POLLUTION BAGHOUSE PULSE - AIR TYPE WITH 750 BAGS 16,000 CFM, 3 COMPARTMENTS	1	H 15 FT W 10 FT L 10 FT dia. dia.	LIGHT GAUZE METAL WALLS, METAL STRUCTURE 3" X 3" X 1/4" ANGLE-IRON BOLTED TO CONCRETE PAD WITH 5/8" BOLTS AT 3 RACES	O	4	4
7	ELECTRIC FURNACE 100 KW, 430 V 400 CYCLE	1	H 5 FT W 10 FT L 2 FT dia. dia.	PIT ON TRUNNIONS HEAVY STEEL SHELL LINED WITH REFRACTORY CONTROL CONSOLE 4' X 2' X 3' STEEL DECK OVER 10' DEEP CONCRETE PIT	O	2	1

COULD ANY STRUCTURE FALL ON EQUIPMENT IF IT PELL IN THE DIRECTION OF THE EQUIPMENT?

METAL FRAMED BUILDING WITH 10' X 26' WINDON AREA  
METAL SIDINGS - NORTH WALL CONCRETE BLOCK  
SEVERE MISSILE PROBLEMS WITH BOTH

\* USE THE BACK OF THIS WORKSHEET FOR SCRATCHES, SKETCHES, OR COMMENTS. LOCATE IF DESIRED

## EXAMPLE SHEET

## ESSENTIAL RATINGS

## REPLACEMENT/REPAIR RATINGS

Rating	Description	Rating	Description
1	<b>Absolutely Essential</b> --- Equipment required to operate during the crisis period to ensure survival supplies for the population. If more than one unit, harden half of units and operate the other half through crisis. If only one unit, shut down and harden, so it will be available post-crisis. (If it is important to survival during the crisis, it should be more important to survival after it.)	1	Impossible --- refers to those items not repairable without new parts from outside, and outside help.
2	<b>Essential to the Process</b> --- Equipment that is a key to some step in the production process which would stop all regular production immediately if it were eliminated, but would not make it impossible to jury rig an alternative process with lower output. (One of a kind for current production level, but do-able via alternative process.)	2	Difficult --- includes those items that would be better sent outside for repair or replacement work, but might be replaced or repaired with some difficulty by implant personnel using materials and equipment on hand.
3	<b>Essential for Normal Operations</b> --- Equipment that is required principally for normal operation of the plant, but for which there are several of a kind with production rate affected by numbers available.	3	Possible --- includes those items that could be repaired by inhouse personnel without too much difficulty using materials and equipment on hand.
4	<b>Non-Essential</b> --- Safety and pollution equipment, and backup equipment used only for occasional peak demand periods.	4	Easy --- refers to items for which many spares or substitute parts are commonly available both onsite and off and which can be repaired with resources on hand, or by simply jury rigging common materials.

Each inventory sheet should be used for one area only. If you start to inventory another area -- start another worksheet. Turn in sheets as they are completed to coordinator.

BUDS  
AREA

EQUIPMENT INVENTORY WORKSHEET

SQUAD MEMBERS

PAGE  
#

ITEM NO.	EQUIPMENT NAME AND DESCRIPTION	QTY	SIZE	REMARKS	SHUT DOWN TIME	E	RR
1	APPROX WEIGHT		H W L DIA.				
2	APPROX WEIGHT		H W L DIA.				
3	APPROX WEIGHT		H W L DIA.				
4	APPROX WEIGHT		H W L DIA.				
5	APPROX WEIGHT		H W L DIA.				
6	APPROX WEIGHT		H W L DIA.				
7	APPROX WEIGHT		H W L DIA.				

\* USE THE BACK OF THIS WORKSHEET FOR SKETCHES SHOWING EQUIPMENT LOCATION IF DESIRED  
COULD ANY STRUCTURE FALL OR EQUIPMENT IF IT FELL IN THE DIRECTION OF THE EQUIPMENT?

PAGE

SQUAD MEMBERS

#

## EQUIPMENT INVENTORY WORKSHEET

AREA

ITEM	EQUIPMENT NAME AND DESCRIPTION	QTY	SIZE	REMARKS	SUIT DOWN TIME		
					E	R	RR
1	ARMOR PLATE	H					
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3	ARMOR PLATE	H					
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		DA					
4	ARMOR PLATE	H					
		W					
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		DA					
5	ARMOR PLATE	H					
		W					
		L					
		DA					
6	ARMOR PLATE	H					
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		DA					
7	ARMOR PLATE	H					
		W					
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\* IF THE BACK OF THIS WORKSHEET FOR SKETCHES SHOWING EQUIPMENT LOCATION, IT PES AND  
CULD ANY STRUCTURE FALL ON EQUIPMENT IF IT FELL IN THE DIRECTION OF THE EQUIPMENT?



ITEM	DESCRIPTION	LOCATION	TIME	REMARKS	CASE
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ITEM	DESCRIPTION	LOCATION	TIME	REMARKS	CASE
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ITEM	DESCRIPTION	WEIGHT	TYPE	REMARKS	SUPPLY	TIME	COST
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2	ANCHOR	100	TON				
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A	WATER TOWER	SAC
B	WATER TOWER	SAC
C	WATER TOWER	SAC
D	WATER TOWER	SAC
E	WATER TOWER	SAC
F	WATER TOWER	SAC
G	WATER TOWER	SAC
H	WATER TOWER	SAC
I	WATER TOWER	SAC
J	WATER TOWER	SAC
K	WATER TOWER	SAC
L	WATER TOWER	SAC
M	WATER TOWER	SAC
N	WATER TOWER	SAC
O	WATER TOWER	SAC
P	WATER TOWER	SAC
Q	WATER TOWER	SAC
R	WATER TOWER	SAC
S	WATER TOWER	SAC
T	WATER TOWER	SAC
U	WATER TOWER	SAC
V	WATER TOWER	SAC
W	WATER TOWER	SAC
X	WATER TOWER	SAC
Y	WATER TOWER	SAC
Z	WATER TOWER	SAC

DOES ANY STRUCTURE FALL ON EQUIPMENT IF IT FELL IN THE DIRECTION OF THE EQUIPMENT?

IF THE PILE OF U.S. WATER TOWER SECTION SHOWN IN MOUNTAIN LOCATED AS DESCRIBED



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REMARKS	#

NAME	ADDRESS	TELEGRAM
John C. Gandy	100 W. 45th St., New York, N.Y.	John C. Gandy
John C. Gandy	100 W. 45th St., New York, N.Y.	John C. Gandy
John C. Gandy	100 W. 45th St., New York, N.Y.	John C. Gandy
John C. Gandy	100 W. 45th St., New York, N.Y.	John C. Gandy

ANALYSTS  
TESTIMONY  
EXHIBITS  
EXPLANATION  
EXPLANATION

APPENDIX E

COULD ANY STRUCTURE FALL ON EQUIPMENT IF IT FELL IN THE DIRECTION OF THE EQUIPMENT?

THE PAGE F-75, VERSO, CONTAINS SKETCHES SHOWING EVIDENCE OF DESIRED LOCATION.

**INDUSTRIAL**

**PROTECTION**

**GUIDE**

**CRISIS RELOCATION  
INDUSTRIAL HARDENING PLAN**

**VULNERABILITY  
&  
PRIORITY  
RATING  
BOOKLET 7**

**SCIENTIFIC SERVICE, INC.**

**CRISIS RELOCATION INDUSTRIAL HARDENING PLAN**

Booklet 7

**VULNERABILITY/PRIORITY RATING & HARDENING DECISIONS**

This is one of ten booklets of the Industrial Hardening Manual  
developed for the  
Federal Emergency Management Agency  
under Contract No. EMW-C-0154, Work Unit 1124E

**SCIENTIFIC SERVICE, Inc.**  
Redwood City, California 94063

Booklet 7

**VULNERABILITY/PRIORITY RATINGS and HARDENING DECISIONS**

Hardening Operations Manager: \_\_\_\_\_  
(name)

Alternate \_\_\_\_\_  
(name)

**Objective:** To determine the relative importance and vulnerability of each item of plant equipment in order to establish priorities (and allocate resources) for hardening.

This booklet is part of the plan to protect equipment from possible damage in the event of a major disaster. It provides approaches to setting hardening priorities. The aim is a methodology to combine systematically, the relative importance to production of each item of equipment and its vulnerability. The combined rating provides a basis for ranking the order in which hardening activities should proceed to deliver the greatest overall reduction in plant vulnerability. It will be based on your assignment of relative importance to operations and on the relative vulnerability of equipment in your plant. Plant personnel assigned to this task should have the ability to recognize alternative production methods that can be used in emergencies to maintain some production when there is damaged or inoperative equipment.

## **PROCEDURE SUMMARY**

A numerical **vulnerability/priority** rating must be determined for each item on the equipment inventory list compiled by the equipment inventory team. The worksheets from this booklet, the completed worksheets from Booklet 6, and Booklet 8 are all required to complete the assignment of vulnerability/priority ratings. This vulnerability/priority rating is a combination of the first item and one or the other of the two remaining items listed below:

- o The essential rating, **E**, and the replacement-repair rating, **RR**, assigned during the equipment inventory. (These ratings are defined on the back of the sample inventory worksheet of Booklet 6 and repeated on page 6, here.)
- o The equipment "Blast" rating obtained from the equipment index and the vulnerability/blast rating catalog, Booklets 8A and 8B.
- o The building "structural" rating, **Z**, if equipment is indoors. If equipment is outdoors and within range of **any** structure once it is toppled, the rating **Z** should be entered under structural, as well.

## **VULNERABILITY/PRIORITY RATING INSTRUCTIONS**

Using the following procedures, work rapidly to establish priorities (rank) of each piece of equipment for hardening:

- STEP 1: Collect the equipment inventory worksheets from the coordinator and lay them out side by side with the hardening decision worksheets to develop the equipment priority ranking (see page 5).
- STEP 2: Number each hardening decision worksheet to correspond to the inventory sheet (see page 5).
- STEP 3: Add the Essential (E) to the Replacement/Repair (RR) rating and record in column A of the hardening decision worksheet.
- STEP 4: Use the Equipment Index and the Vulnerability/Blast Rating Catalog, Booklets 8A and 8B, to determine the blast rating (survival rating with protective housekeeping) for each piece of equipment and record on the worksheet (column B).

STEP 5: If the equipment is not located in an area where collateral damage\* can occur, record "n/a" (not applicable) in column C. If the equipment could be heavily damaged by parts of the building and/or adjacent structures (the assumption is to be made that these fall over), enter "2" in column C.

STEP 6: Take the smaller of the two ratings from column B, "blast", or column C, "structural", and add it to column A, "E + RR", to determine the priority rating (**PR**) of the equipment:

$$PR = \text{Col. A} + \text{Col. B} \quad \text{or} \quad \text{Col. A} + \text{Col. C} \quad (\text{whichever is lower})$$

Where Col. C is "na", use Col. B.

Record PR value in column marked "Priority" on worksheet.

Once all the priorities are entered, the **lowest** number identifies the weakest link(s) in production equipment that most need to be hardened (see example on page 5). The major hazard to each item will be evident (often the building that houses the equipment).

STEP 7: Redline all items below a priority rating of 8 for immediate attention; then proceed with hardening decisions (see page 7).

\* Collateral damage is damage caused by buildings collapsing or toppling over, flying bricks, etc.



## ESSENTIAL RATINGS

## REPLACEMENT/REPAIR RATINGS

Rating	Description	Rating	Description
1	<b>Absolutely Essential</b> --- Equipment required to operate during the crisis period to ensure survival supplies for the population. If more than one unit, harden half of units and operate the other half through crisis. If only one unit, shut down and harden, so it will be available post-crisis. (If it is important to survival during the crisis, it should be more important to survival after it.)	1	<b>Impossible</b> --- refers to those items not repairable without new parts from outside, and outside help.
2	<b>Essential to the Process</b> --- Equipment that is a key to some step in the production process which would stop all regular production immediately if it were eliminated, but would not make it impossible to jury rig an alternative process with lower output. (One of a kind for current production level, but do-able via alternative process.)	2	<b>Difficult</b> --- includes those items that would be better sent outside for repair or replacement work, but might be replaced or repaired with some difficulty by implant personnel using materials and equipment on hand.
3	<b>Essential for Normal Operations</b> --- Equipment that is required principally for normal operation of the plant, but for which there are several of a kind with production rate affected by numbers available.	3	<b>Possible</b> --- includes those items that could be repaired by inhouse personnel without too much difficulty using materials and equipment on hand.
4	<b>Non-Essential</b> --- Safety and pollution equipment, and backup equipment used only for occasional peak demand periods.	4	<b>Easy</b> --- refers to items for which many spares or substitute parts are commonly available both onsite and off and which can be repaired with resources on hand, or by simply jury rigging common materials.

Each inventory sheet should be used for one area only. If you start to inventory another area --- start another worksheet. Turn in sheets as they are completed to coordinator.

## **HARDENING METHOD DECISION PROCESS**

### **1. Review Requirements**

- A. Determine the highest priority equipment (that with the lowest numbered priority rating). This should establish a reduced list of equipment that should be hardened first.
- B. Determine the source of equipment damage from the equipment inventory survey (according to equipment location). Damage sources are:
  - (1) Building collapse (impact of heavy walls, floors, roof, building frame)
  - (2) Missiles (impact of wall sheathing, bricks, concrete blocks, etc., from structures)
  - (3) Drag (high winds on unsecured equipment leading to overturning, sliding, and impact)
  - (4) Fire (damage initiated, spread to debris, cutting oils, solvents, etc.)
  - (5) Pressure-caused equipment collapse
  - (6) Electromagnetic pulse (from thermonuclear pulse)

### **2. Review Resources**

- A. Manpower: Estimate the number of personnel available for hardening tasks (Plan to evacuate: 20%, Day 1; 30% more, Day 2; remainder, Day 3).
- B. Equipment, materials, and tools: Review the data obtained from the hardening resources inventory team.
- C. Time: Estimate the amount of time available to accomplish hardening tasks.

3. Develop a list of possible hardening methods:

A. Consider all possible variations (Booklet 9) of the following basic hardening alternatives:

- (1) Evacuate to safe location (transport to distant low-risk area). First choice wherever practical.
- (2) Move to new location and harden (improve location within building or move outdoors).
- (3) Harden in place (for difficult to move equipment).
- (4) Harden replacement equipment or alternative process equipment.

4. Evaluate each hardening method -- Test for "acceptability" and improved outcome. Primary criteria for acceptance are:

A. Resources are available (possible to accomplish) -- manpower, equipment, tools, materials and time are available to accomplish hardening method.

B. Method is expedient -- accomplished in short period of time.

C. Significantly improves survival blast rating.

D. Significantly reduces the recovery time.

5. Choose the hardening method that is the best blend of 4A through 4D and allows as many pieces of equipment to be treated as possible.

6. Fill in the appropriate data on the Hardening Decision Worksheet and assign teams, resources, and a schedule to complete.

**EQUIPMENT INVENTORY WORKSHEET #** PAGE **2**

**ALO SITE BUILDINGS AREA**

**FIGURE # 2 HARSHENING DECISION WORKSHEET**

ITEM #	EQUIPMENT NAME AND DESCRIPTION	SIZE	REMARKS	SHUT DOWN TIME	E RR	HARSHENING METHOD	MATERIALS REQUIRED	HARSHENING	
								1	2
1	TRIM AND STAMP TABLE WITH Dies AND PREHEAT CYLINDER (24" IN DIAMETER, 3-IN. NUTTER)	5'	1-IN THICK TABLE TOP NOT APPLIED VERY HEAVY	0 4 2 0 0 2 0	0 4 2 0 0 2 0	INVERT PLACE NEXT TO CONCRETE CURE	FORKLIFT HAND TOOLS	USE 4 T-2	50
2	WELDING AREA WITH PORTABLE WELDER (MIG)	5'	SMALL WELDERS AND TABLES	0 2 2 4 4 2 0	0 2 2 4 4 2 0	EVALUATE WELDERS INVERT TABLES	FORKLIFTS RAMP	USE 4 T-2	13.2
3	WATER TEST (DIP) TANK FOR TESTING RADIATORS	3'	NOT APPLIED	0 2 4 0 2 2 0	0 2 4 0 2 2 0	DO LAST!	LEAVE FULL AFFIX TO FLOOR	USE 4 T-2	10.2
4	CONTAINERS WITH WELDERS ON ADDS BOTTOM PLATE 16' SQUARE	4'	WITH FOUR 1/2-IN. BOLTS	0 4 3 7 3 2 0	0 4 3 7 3 2 0	UNBOLT AND EVALUATE	SMALL FORKLIFT HAND TRAILERS	USE 4 T-2	25
5	4,000-lb CAPACITY FORKLIFT	4'	SOLID-TIRED LPG-Powered HANDLES	0 2 3 5 0 2 7	0 2 3 5 0 2 7	PUT ON TRUCK LAST AND EVALUATE WITH PATTERNS AND DIES	RAMP TO TRUCK HAND TRAILERS	USE 4 T-2	10.2
6	DIES AND PATTERNS	various				DO LAST!	PUT ONE IN EACH PRESS AND CLOSE EVALUATE ALL OTHERS	USE 4 T-2	10.2
7	MATERIAL STACKS	various					BAND TOGETHER, WE FLAT SOME STACKS PLACED BETWEEN PLATES OF PRESSES SOE EVALUATED	USE 4 T-2	10.2

DESCRIBE POSSIBLE COLLATERAL DAMAGE  
ITEMS OF FINISHED RADIATORS, BUMPERES AND FENDERS NEAR  
WALLS; SOME IN OPEN, SLATTED CRATES, SOME ON RAILCAR  
OUT OF THIS WORKSHEET TAKE NOTES TOWARDS EQUIPMENT LOCATION TO DETERMINE

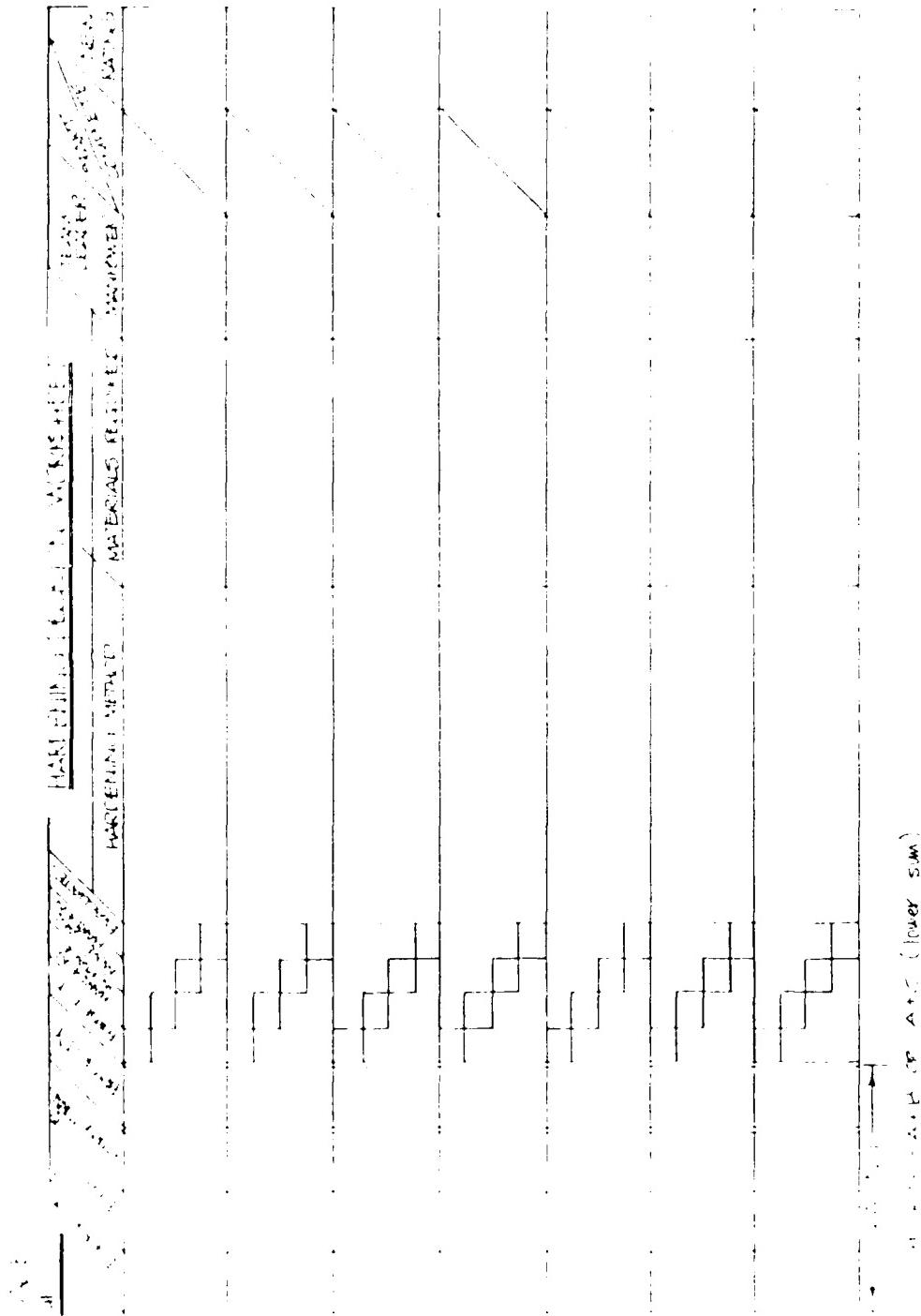
This sheet is from Booklet No. 6  
out of this worksheet take notes towards equipment location to determine

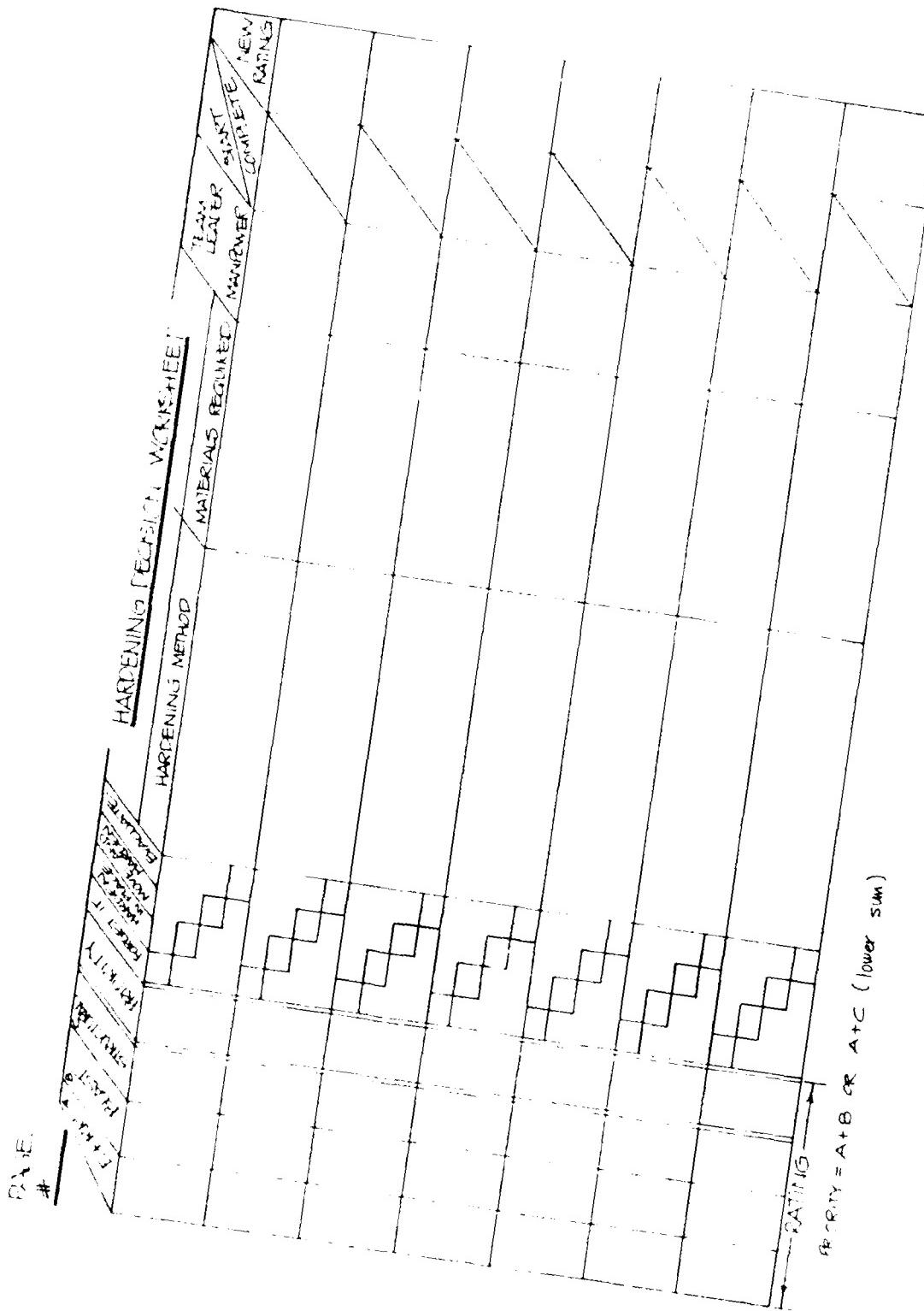
Decision Making  
See pages 6-7

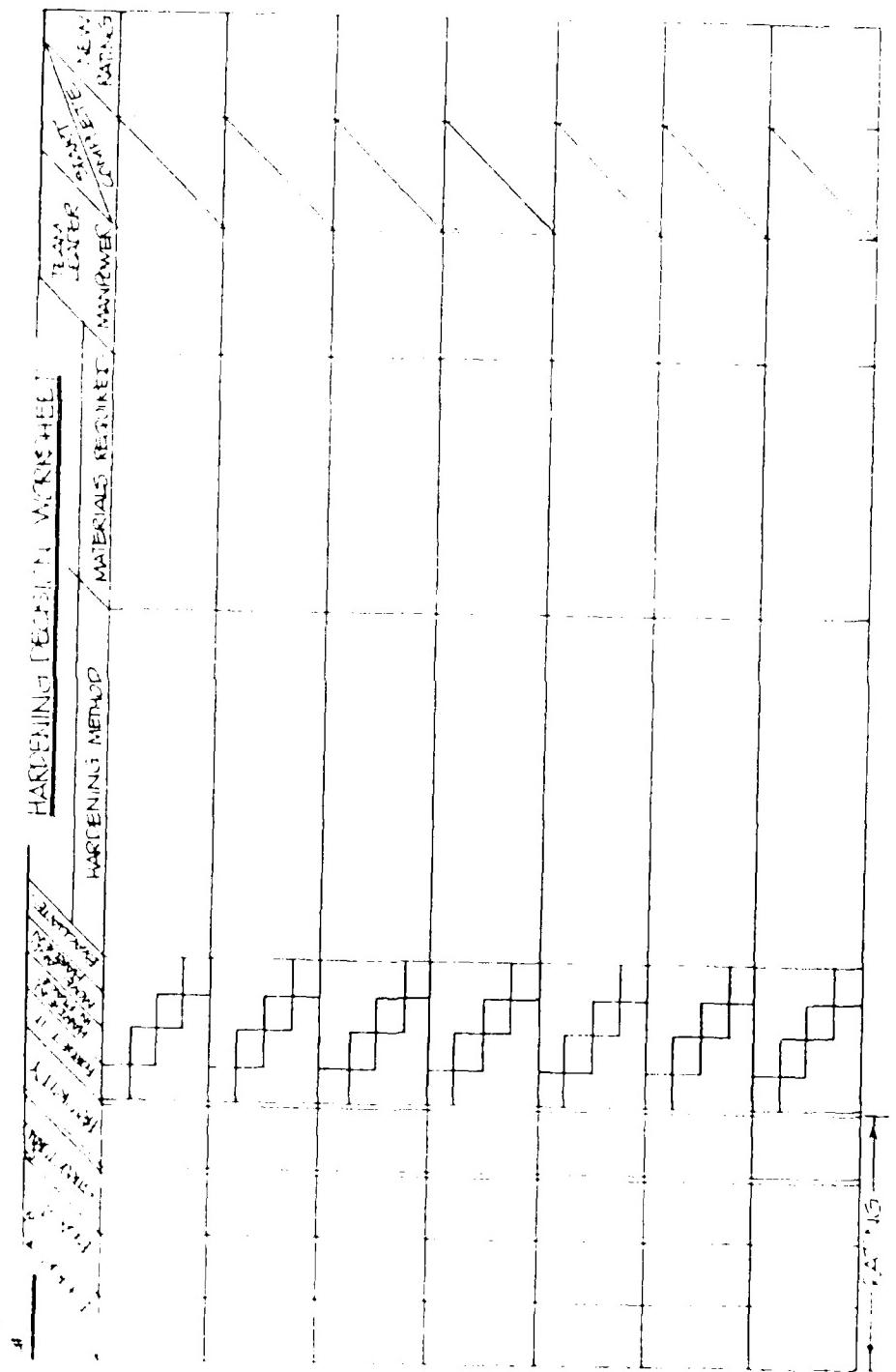
Hardening Options Decision Selection

PRIORITY =  $E + RR + BLAST - OR - STRUCTURAL$  USE LOWER SUM

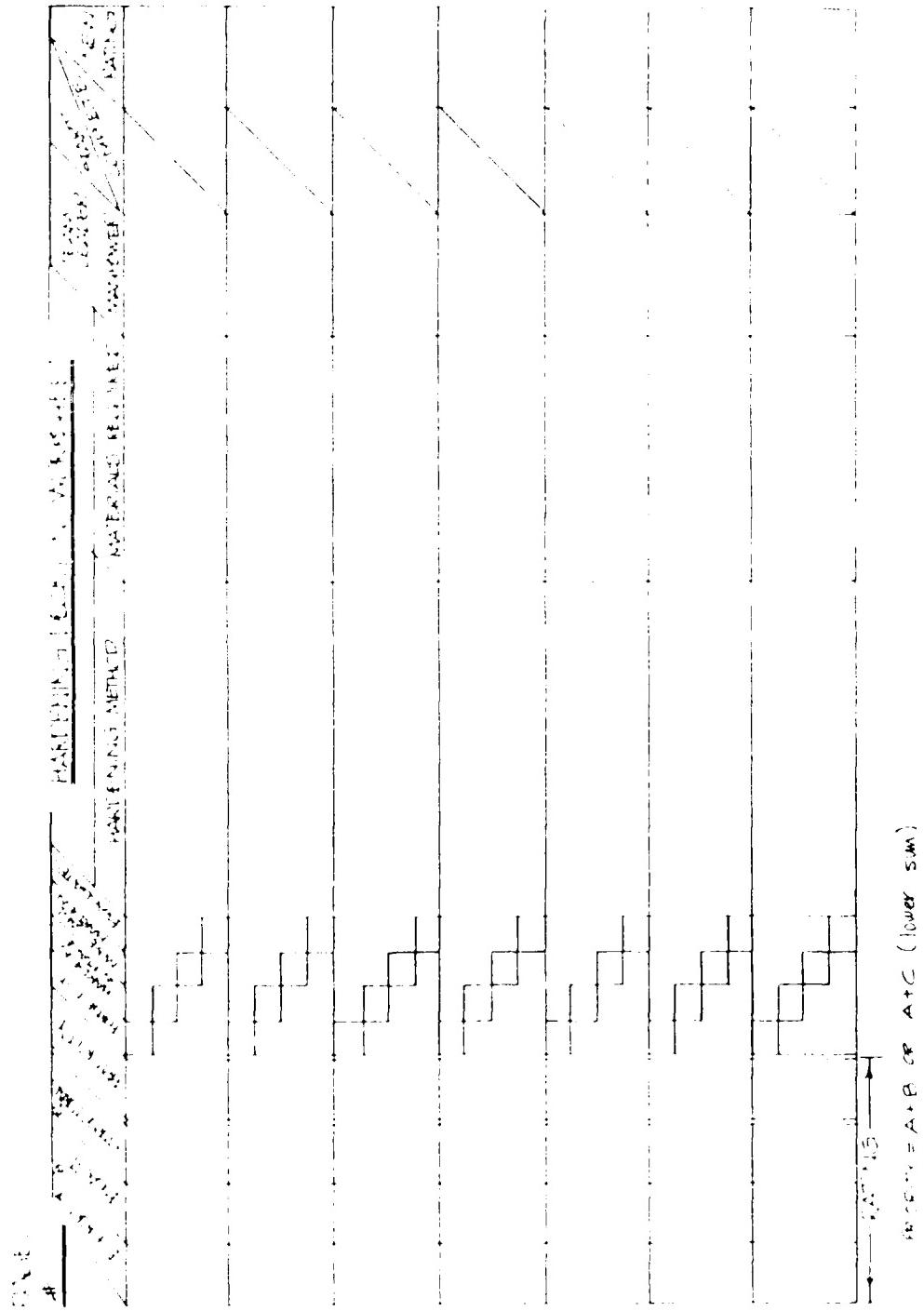
For "Structural" use 2  
If N/A then use Blast Rating  
Blast Ratings are found in Booklet 2  
"Vulnerability / Blast Rating Catalog"

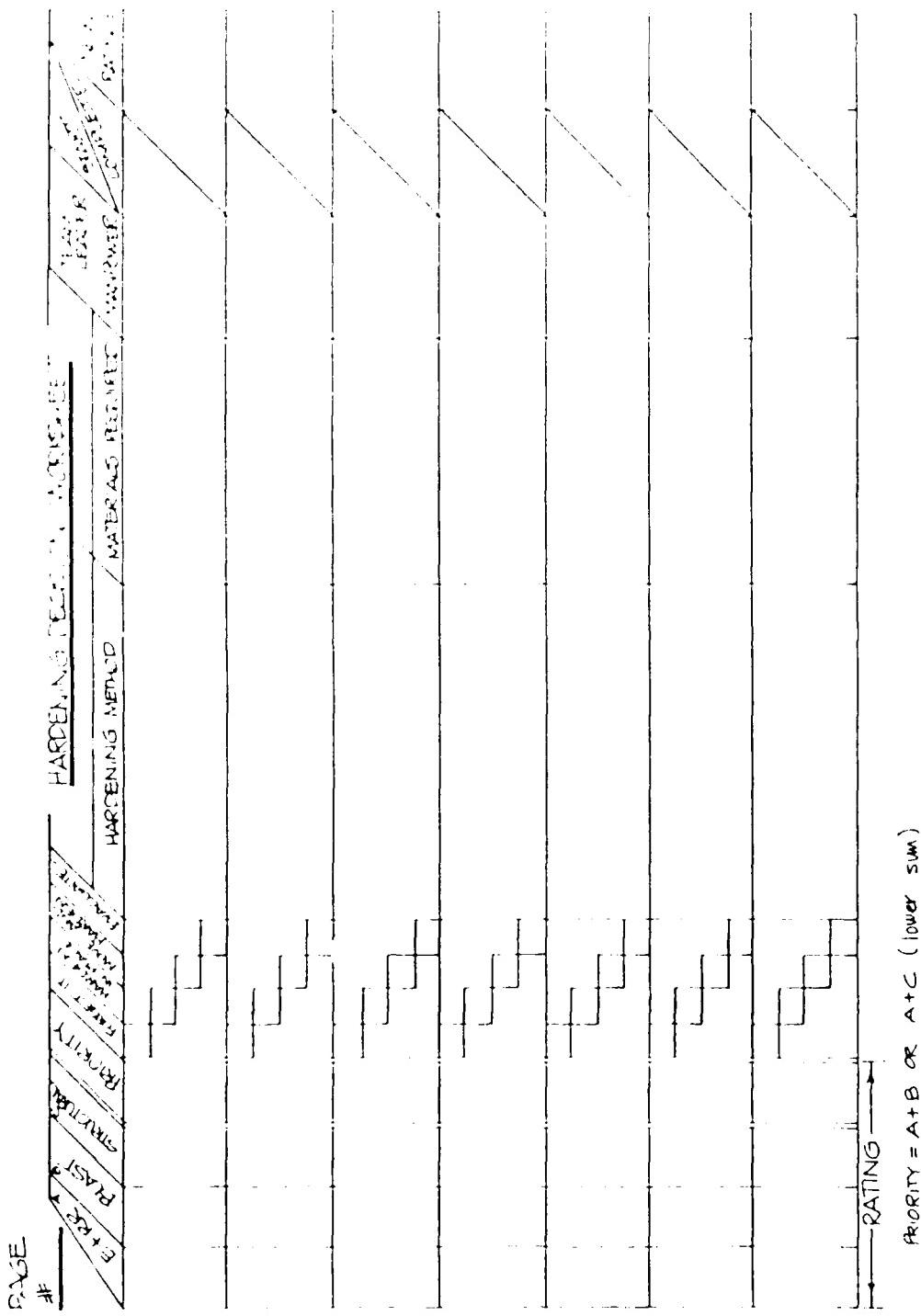


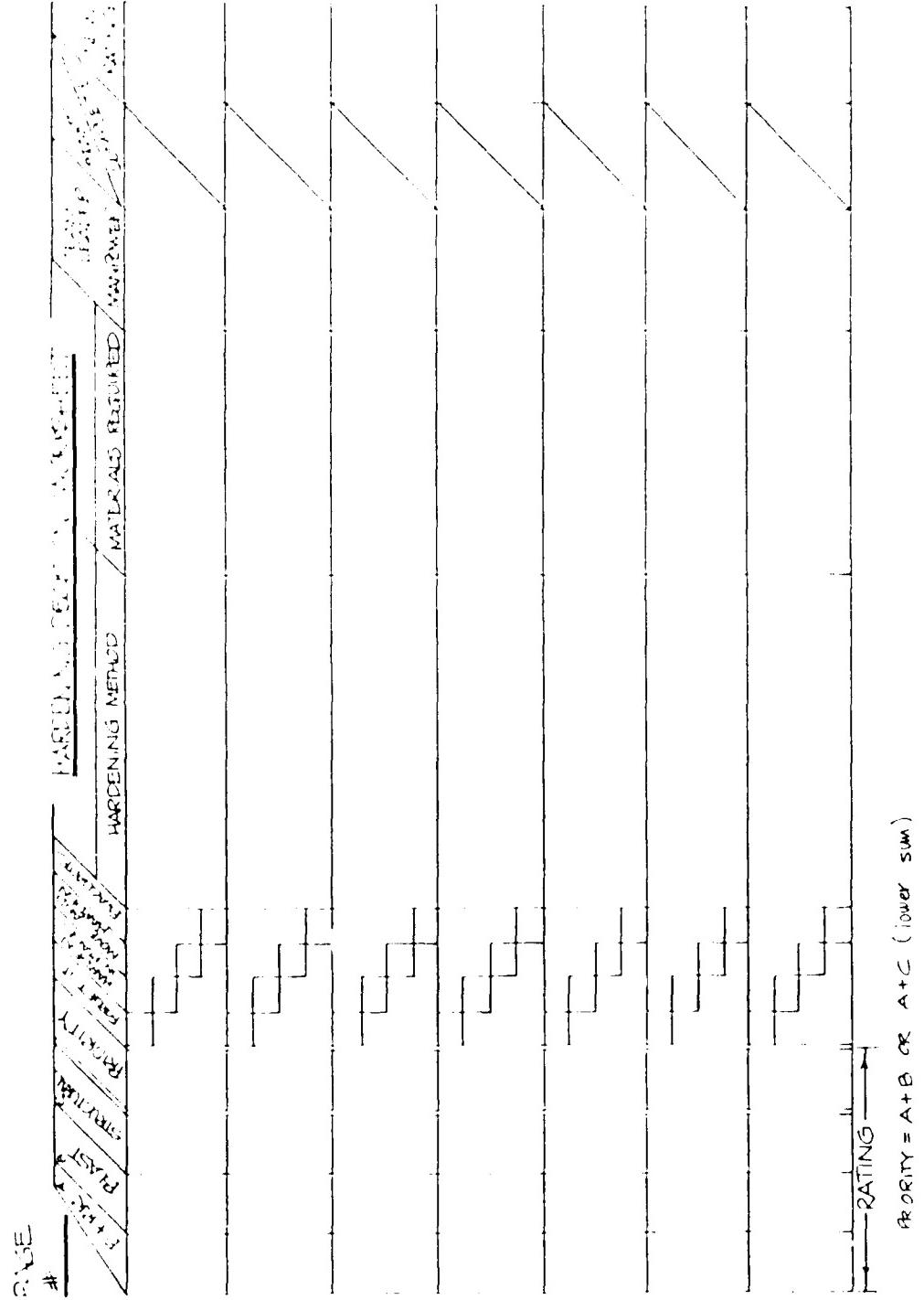


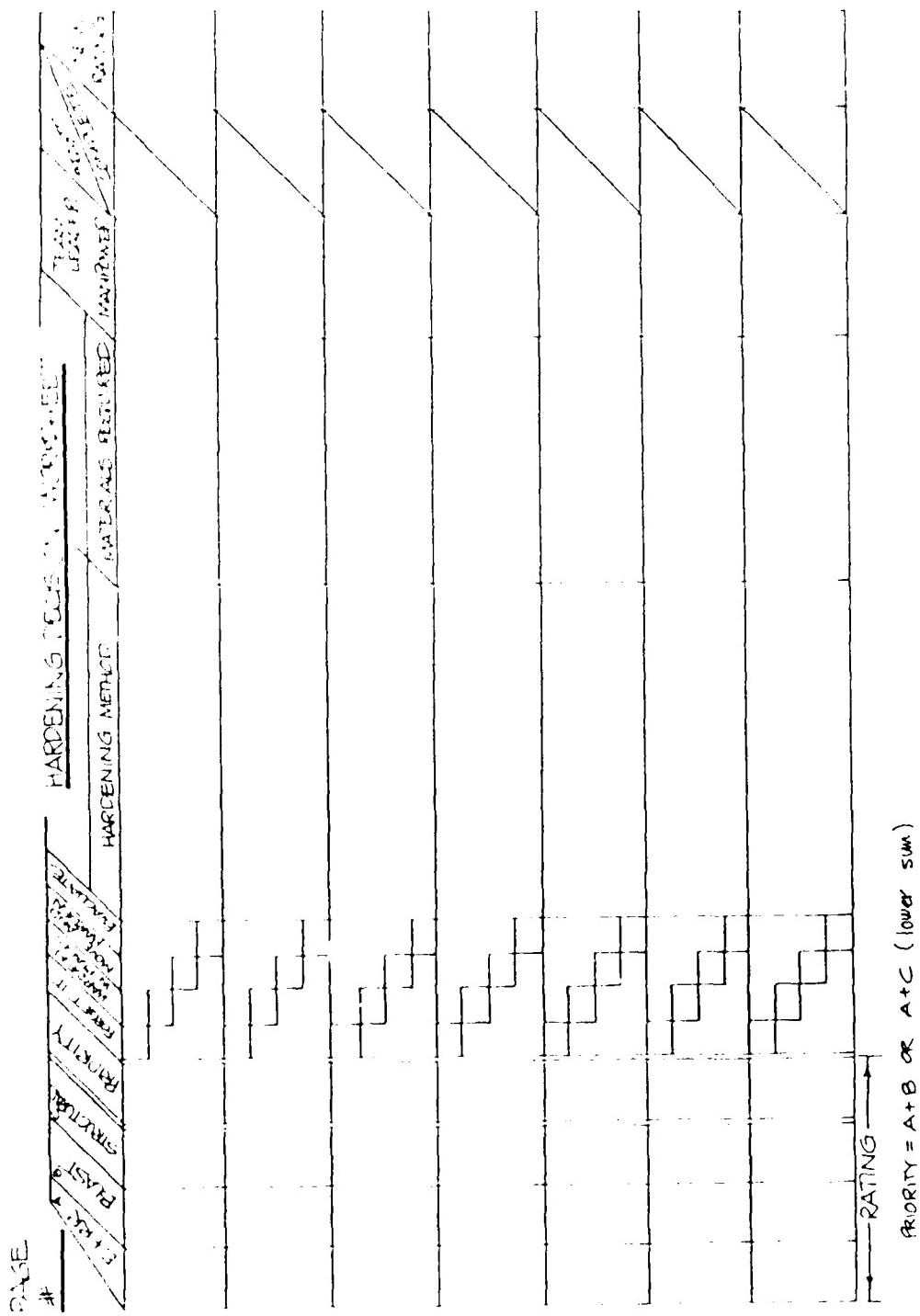


$$T_{\text{total}} = A + B \text{ OR } A + C \text{ (lower sum)}$$









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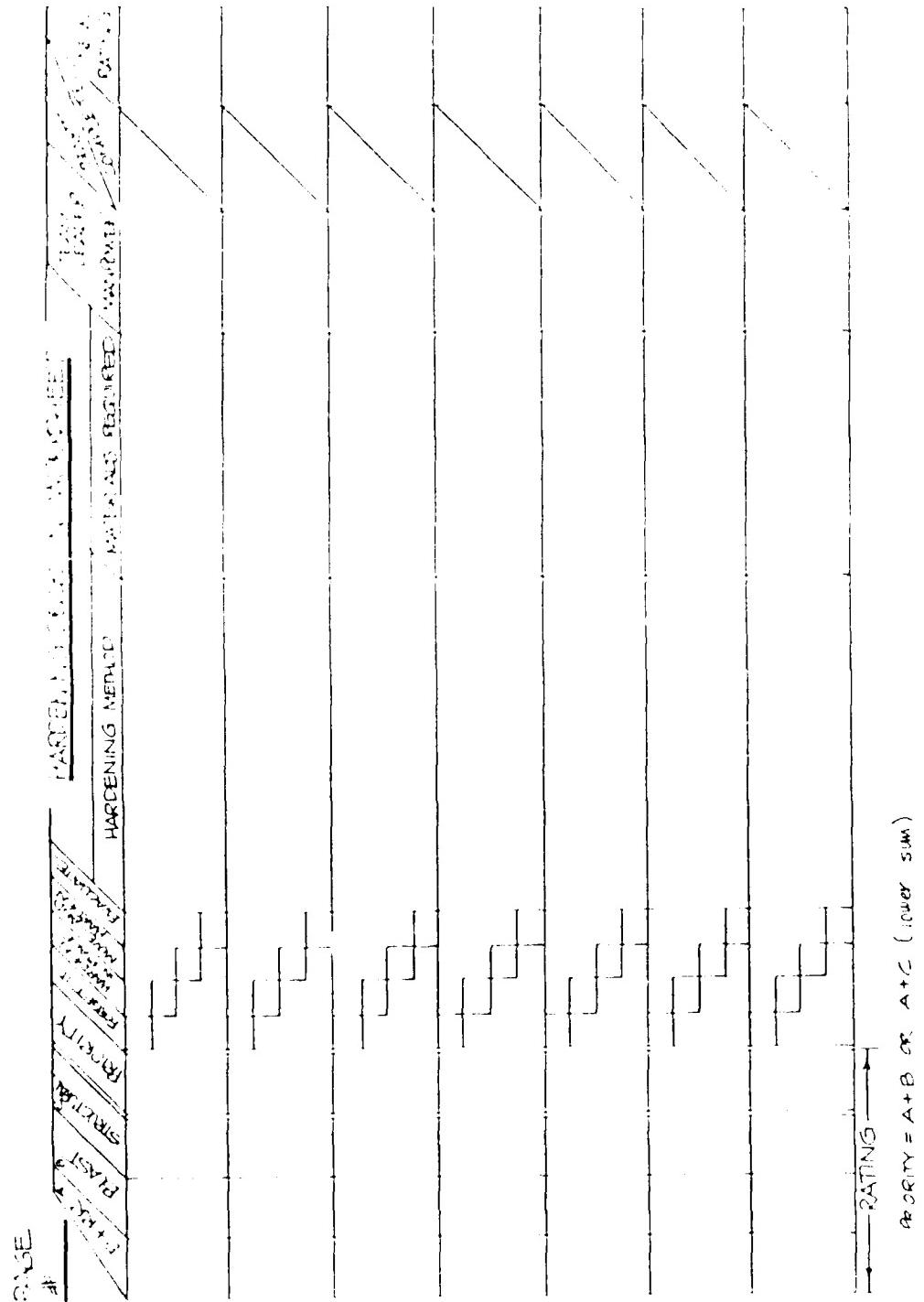
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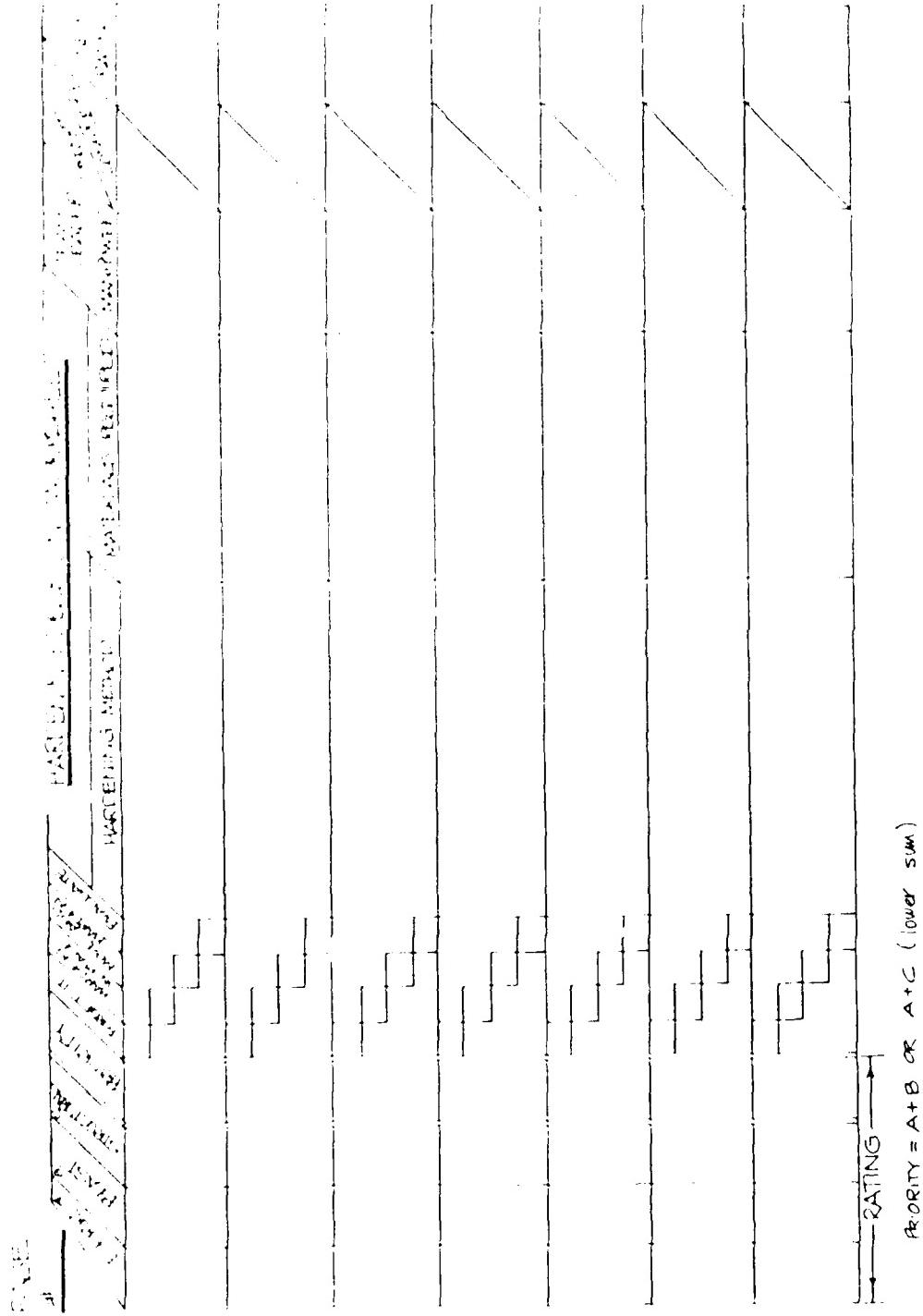
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HARTENIG, MARY - WATER AS PEST AT HOP PLANTATION

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# **INDUSTRIAL**

# **PROTECTION**

# **GUIDE**

**CRISIS RELOCATION  
INDUSTRIAL HARDENING PLAN**

**VULNERABILITY  
BLAST RATING  
CATALOG  
&  
EQUIPMENT  
INDEX  
BOOKLET 8**

**SCIENTIFIC SERVICE, INC.**

**CRISIS RELOCATION INDUSTRIAL HARDENING PLAN**

**Booklet 8A**

**VULNERABILITY/BLAST RATINGS CATALOG**

This is one of ten booklets of the Industrial Hardening Manual  
developed for the  
Federal Emergency Management Agency  
under Contract No. EMW-C-0154, Work Unit 1124E

**SCIENTIFIC SERVICE, Inc.**  
**Redwood City, California 94063**

**Booklet 8A**

**VULNERABILITY/BLAST RATING CATALOG**

**Hardening Operations Manager:** \_\_\_\_\_  
(name)

**Alternate:** \_\_\_\_\_  
(name)

**Objective:** To find equipment blast ratings (to enter in column B of worksheets provided in Booklet 7).

To find a way to protect your equipment you must find its vulnerability to a blast wave.

Blast ratings are affected by:

1. Equipment weight
2. Equipment size
3. How equipment is made
  - (a) Framework, coverings
  - (b) Internal or external parts that are essential to its functioning
4. The ratio of height to the smaller dimension of the base it stands on.

**TO DETERMINE THE BLAST RATING OF A PIECE OF EQUIPMENT:**

1. Find it in the Equipment Index (Booklet 8B, attached) and obtain the category designation located to the right of the page.

The category designation is in three parts consisting of Group (Numbers 1-3), Section (Letters A-G), and Class (Numbers 1-4). This catalog is color-coded so that:

- Group 1 is pink. Items fit into a box 4 x 4 x 8 feet (so would fit a truck bed)
- Group 2 is green. Items fit into a box 15 x 15 x 20 feet (but not a group 1 box)
- Group 3 is yellow. Items too large to fit a group 2 box.

2. Look up category designation in this catalog (starting after page 10) and get the "Survival Blast Rating with Protective Housekeeping," according to whether it is "secured" or "unsecured." If protective housekeeping is physically impossible, use the Light-to-Moderate damage rating according to whether the item is "secured" or "unsecured". (If a violent earthquake could tip it over, it is "unsecured" even if it is fastened; e.g., tall pieces of equipment on small bases.)

3. For Blast Rating listings -- Each page is divided into **Low Profile (H/B  $\leq$  2)** and **High Profile (H/B > 2)**. From the dimensions logged on the equipment inventory sheet, decide which to use.

Definitions:

- (H/B  $\leq$  2): The height is less than, or equal to, two times the smaller dimension of the base.
- (H/B > 2): The height is over two times the smaller dimension of the base.

4. Enter the appropriate Blast Rating number on the Booklet 7 decision worksheet under BLAST (column B).

If the machine is not listed where you look first, try to find it under another name. If you still cannot find it, look up the name of a couple of pieces of equipment built like the one you're looking for, and use an average for those categories, since things built alike react somewhat alike to blast effects.

If you can't find a rating category by any of these methods, use your best judgment and fit the item to the list of equipment categories that follow (pages 5 - 10):

- o Look in the proper **size group** (listed at the bottom of pages 5 -10)
- o Find the **section** in that group that is closest to your machine's type. Each of the three size groups is divided into sections (A, B, C, etc.) representing different types of equipment.
- o Pick the description under **class** that fits best. Each section has two or more classes (A-1, A-2, etc.) of equipment.

See example on the following page.

**EXAMPLE: Roll Forming Machine — H = 5', W = 12', L = 6' (not in Index 8B)**

5' x 12' x 6'	Size Group 2*
Medium & heavy duty machinery	Section A**
Heavy frame construction	Class 2

**Equipment Category -- 2A-2**

H/B = 5/6 (H over the smaller of W and L)

Look up this category number (also the page number in the bottom left-hand corner) in the corresponding color-coded Vulnerability Ratings section, following page 10 (coded green for this example) and get the Blast Rating.

Enter this Blast Rating in column B on the decision worksheet from Booklet 7.

Page 2A-2 shows ratings for  $H/B \leq 2$ . If protective housekeeping is completed, the rating is 6, provided the machine is outdoors away from structures and secured. It is 4 if the machine is outdoors, away from structures and unsecured. Without housekeeping, loose items become missiles, so that, even secured, the rating would be 3 (light to moderate damage) or 6 (moderate to heavy damage). Indoors, the building will collapse on it at 2 psi, the structure rating, so the rating would be 2.

\* Color-coded green. Start on page 7 and look for **section** that best fits.

\*\* With **section** established, select **class** that best fits.

AD-A102 631 SCIENTIFIC SERVICE INC REDWOOD CITY CA  
INDUSTRIAL PROTECTION MANUAL. (U)

F/G 15/3

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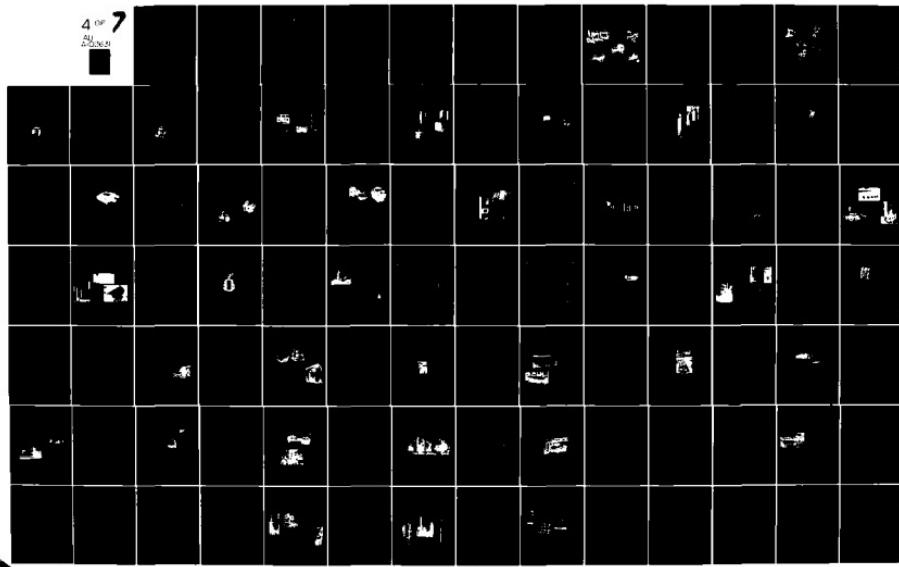
SSI-8011

EMW-C-0154

NL

UNCLASSIFIED

4 OF 7  
400000



**SECTION A: SMALL MACHINERY/MECHANICAL EQUIPMENT**

<b>CLASS</b>	<b>EXAMPLE</b>
1. Portable lightframe equipment	Portable heaters, steam boilers, blowers, air conditioners
2. Skid or frame-mounted mechanical equipment	Compressors, hoists, vacuum pumps, liquid pumps
3. Machine tools/metal & wood working equipment	Light drill presses, band saws, lathes presses

**SECTION B: ELECTRICAL/ELECTRONIC EQUIPMENT AND INSTRUMENTATION**

<b>CLASS</b>	<b>EXAMPLE</b>
1. Rugged portable electrical equipment	All metal power hand tools
2. Delicate portable electrical and panel/rack/machine mounted equipment	Plastic encased power hand tools, flowmeters, temperature recorders, meters, gauges, amplifiers, oscilloscopes
3. Electrical power distribution equipment	Insulators, standoffs, capacitors, circuit breakers (free-standing)
4. Motors	A.C. and D.C. motors

**INDUSTRIAL EQUIPMENT CATEGORIES — GROUP 1: < 4' x 4' x 8', < 1,000 lb.**

**SECTION C: THIN-WALLED CONSTRUCTION, BINS, DRUMS, etc. (Use for Hardening Resource, Booklet 5)**

CLASS	EXAMPLE
1. Containers	File cabinets, "tote" boxes, hoppers, desks, 55-gallon drums, bins, trays
2. Hoods, cabinets, enclosures	Paint spray booths, fume hoods, machine covers and guards, fan housings

**SECTION D: PRESSURE VESSELS/HEAVY-WALLED VESSELS**

CLASS	EXAMPLE
1. Portable pressurized bottles and cylinders	High pressure gas cylinders, liquefied gas bottles
2. Fixed heavy-walled vessels	Cook kettles, autoclaves, centrifuges

**INDUSTRIAL EQUIPMENT CATEGORIES — GROUP 1: < 4' x 4' x 8', < 1,000 lb.**

**SECTION A: MEDIUM & HEAVY DUTY MACHINERY/MECHANICAL EQUIPMENT**

CLASS	EXAMPLE
1. Light frame construction	Separators, sifters and classifiers, screw mixers, light commercial printing presses
2. Heavy frame construction	Injection molding presses, extruders, forges, milling machines, casting machines

**SECTION B: ELECTRICAL/ELECTRONIC UNITS & PROCESS CONTROL**

CLASS	EXAMPLE
1. Electrical generating equipment* (*Resource: move portable units out)	Emergency or standby units, cogeneration systems, battery arrays
2. Electrical/electronic panels and racks	Moderately sized power panels, process control panels, electric equipment racks, instrumentation panels
3. Electrical power equipment	MVA transformers, free standing circuit breakers, large switchgear
4. Motors	

**SECTION C: THIN-WALLED CONSTRUCTION (Use for Hardening Resource, Booklet 5)**

CLASS	EXAMPLE
1. Movable items	Dumpsters, "tote" boxes, shipping containers
2. Stationary floor/pad mounted	Sandblast cabinets, paint spray booths, noise enclosures, material bins, light storage tanks
3. Elevated constructions	Hoppers, elevated tanks, baghouses

**INDUSTRIAL EQUIPMENT CATEGORIES — GROUP 2:  $\leq 15' \times 15' \times 20'$ ,  $\leq 30,000$  lb.**

**SECTION D: HEAVY-WALLED OR PRESSURE VESSELS**

<b>CLASS</b>	<b>EXAMPLE</b>
1. Movable	Transfer tanks, LPG trucks
2. Stationary liquid or gas storage	LPG storage, high pressure gas storage
3. Material processing	Autoclaves, reactors

**SECTION E: MECHANICAL HANDLING EQUIPMENT**

<b>CLASS</b>	<b>EXAMPLE</b>
1. Mobile*	Forklifts, loaders
2. Movable-tracked/limited	Bridge cranes, monorail crane, balance arms
3. Stationary	Conveyors, can/bottle handlers and fillers, material elevators

**SECTION F: REFRACTORY OR MASONRY WALLED EQUIPMENT**

<b>CLASS</b>	<b>EXAMPLE</b>
1. Simple constructions	Box type furnaces, ovens
2. Other lined equipment	Boilers, arc and induction furnaces, stacks to 30 feet, small calciners, ladles

\* Potential resource.

**INDUSTRIAL EQUIPMENT CATEGORIES — GROUP 2: ≤ 15' x 15' x 20', ≤ 30,000 lb.**

**SECTION A: LARGE MECHANICAL EQUIPMENT**

<b>CLASS</b>	<b>EXAMPLE</b>
1. Assemblies and light-framed constructions	Printing presses, looms
2. Heavy frame equipment	Large presses, large forges, slab/billet mills

**SECTION B: UTILITY DISTRIBUTION EQUIPMENT**

<b>CLASS</b>	<b>EXAMPLE</b>
1. Power generating equipment	Generators — MVA class
2. Panels and racks (heavy frame, enclosed)	Main distribution panels
3. Distribution equipment	Powerlines, air lines, conduits, buses
4. Substation-type equipment	MVA class breakers, main transformers

**SECTION C: LIGHT-WALLED CONSTRUCTION (Use for Hardening Resource, Booklet 5)**

<b>CLASS</b>	<b>EXAMPLE</b>
1. Mobile, temporary	Temporary vision screens (walls), large doors and covers
2. Enclosures and rooms	Sandblast cabinets, paint spray booths, Equipment sheds, noise enclosures
3. Material storage units	Large bins, tanks
4. Elevated constructions	Baghouses, large hoppers, cooling "towers"

**INDUSTRIAL EQUIPMENT CATEGORIES — GROUP 3: > 15' x 15' x 20', > 30,000 lb.**

**SECTION D: HEAVY-WALLED AND PRESSURE VESSELS**

CLASS	EXAMPLE
1. Mobile* (*potential resource)	LPG trucks, high pressure gas trucks
2. Stationary liquid or gas storage	LPG storage, LNG storage
3. Material processing	Autoclaves, reactors, "cat" crackers

**SECTION E: MECHANICAL MATERIAL HANDLING EQUIPMENT**

CLASS	EXAMPLE
1. Mobile* (*potential resource)	Locomotives, large trucks/carriers
2. Movable-tracked/limited	Large bridge cranes, monorail cranes, rail car dumpers, portable conveyors
3. Stationary	Can feeders, conveyors, material elevators

**SECTION F: REFRACTORY/MASONRY-WALLED EQUIPMENT**

CLASS	EXAMPLE
1. Simple constructions	Box-type furnaces & ovens, masonry buildings & vaults, concrete block structures
2. Special lined equipment	Boilers, arc & induction furnaces, calciners
3. Stacks	Refractory/brick chimneys and stacks

**SECTION G: METAL TOWERS AND COLUMNS**

CLASS	EXAMPLE
1. Assemblies	Transmission towers, scaffolding, catwalks
2. Rigid constructions	Distillation towers, cat crackers, metal stacks

**INDUSTRIAL EQUIPMENT CATEGORIES — GROUP 3: > 15' x 15' x 20', > 30,000 lb.**

VULNERABILITY RATINGS

GROUP 1

TYPE:

**PORTABLE LIGHT FRAME EQUIPMENT**

Maximum Dimensions: (4x4x8) Feet

— Maximum Weight: 1,000 Pounds

EQUIPMENT PAGE NO.

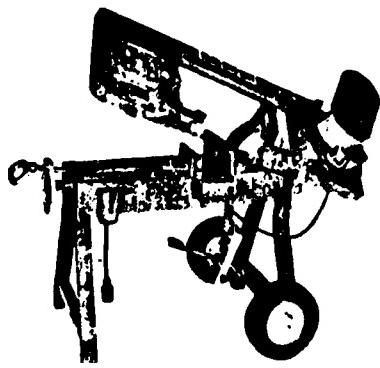
IA-1



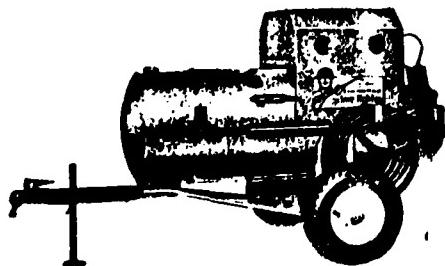
Portable Mixer

EXAMPLES

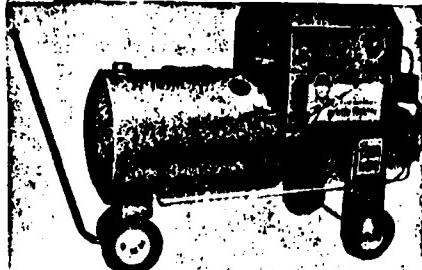
- Portable Blowers
- Portable Heaters
- Window Type Air Conditioners
- Portable Pumps
- Steam "Jennies"



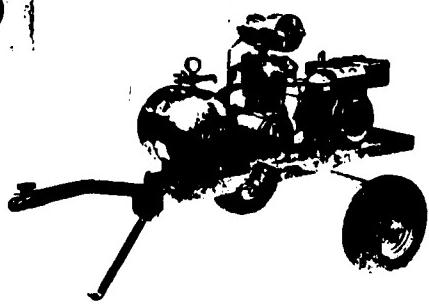
Mobile Band Saw



Portable Steam Cleaner



Steam Cleaner



Portable Compressor

VULNERABILITY RATINGS

GROUP 1

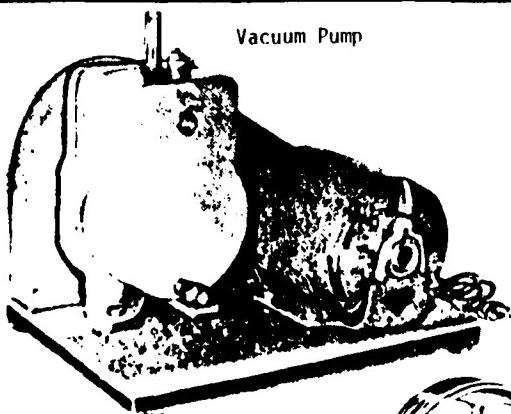
GROUP: 1A-1 PORTABLE LIGHT FRAME EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	SECURED	NOT SECURED	MANHOURS	DAYS	
HORIZONTAL CONFIGURATION ( H/B ≤ 2 )					
1. <u>Little or no damage:</u>				-	-
2. <u>Light to moderate damage:</u> Small tanks broken off, gauge metal covers damaged, minor frame damage	-	1.0	1.0	8	1
3. <u>Moderate to heavy damage:</u> Frame requires major repair or replacement; electric motors broken; new covers, pulleys, fan belts, etc. required	4	3	2	40	7
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	4	2		2	0.5
VERTICAL CONFIGURATION ( H/B > 2 )					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>					
3. <u>Moderate to heavy damage:</u>					
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING					

SKID OR FRAME MOUNTED MECHANICAL EQUIPMENT

EQUIPMENT PAGE NO.

IA-2

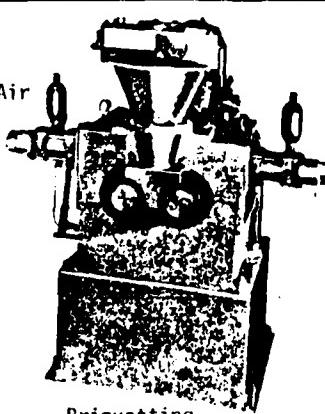
TYPE: Maximum Dimensions: (4x4x8) Feet — Maximum Weight: 1,000 Pounds



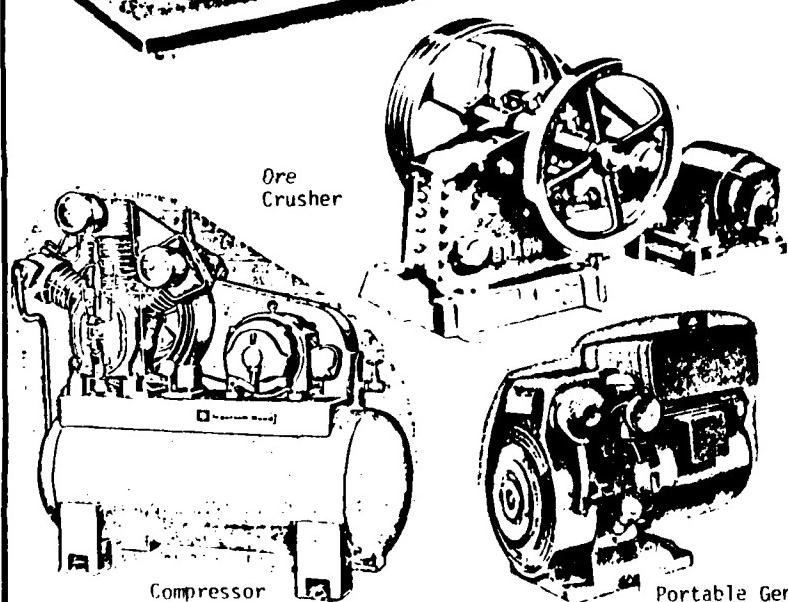
Vacuum Pump

EXAMPLES

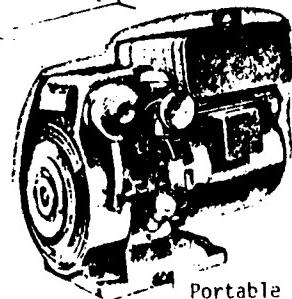
- Liquid Pump Units
- Refrigeration, Fixed Air Conditioning Units
- Compressors
- Hoists
- Vacuum Pumps
- Hydraulic Pumps



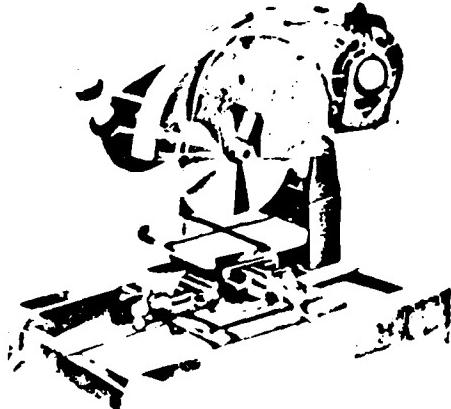
Briquetting Machine



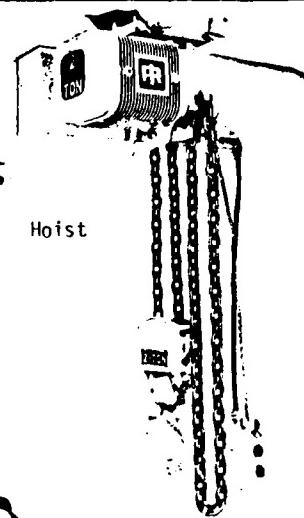
Ore Crusher



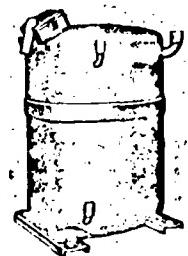
Compressor



Cutoff Saw



Hoist



Sealed Compressors

GROUP: 1A-2 SKID OR FRAME MOUNTED MECHANICAL EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	SECURED	NOT SECURED	MANHOURS	DAYS	
DAMAGE DESCRIPTION					
HORIZONTAL CONFIGURATION ( H/R ≤ 2 )					
1. <u>Little or no damage:</u>				-	-
2. <u>Light to moderate damage:</u> Damaged piping, gauges, control boxes, handles, fan belts, small valves, etc.	2	2	1.5	8	1
3. <u>Moderate to heavy damage:</u> Motors broken; minor frame damage; new controls required	10	6	4	40	15
4. <u>Destroyed:</u> Replacement equipment required					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING					
VERTICAL CONFIGURATION ( H/B > 2 )					
1. <u>Little or no damage:</u>				-	-
2. <u>Light to moderate damage:</u> (see above)	2	1.5	1.5	8	1
3. <u>Moderate to heavy damage:</u> (see above)	8	4	3	40	15
4. <u>Destroyed:</u> Replacement equipment required					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING					
PAGE 1A-2	SKID OR FRAME MOUNTED MECHANICAL EQUIPMENT				

MACHINE TOOLS/METAL AND WOOD WORKING EQUIPMENT

EQUIPMENT PAGE NO.

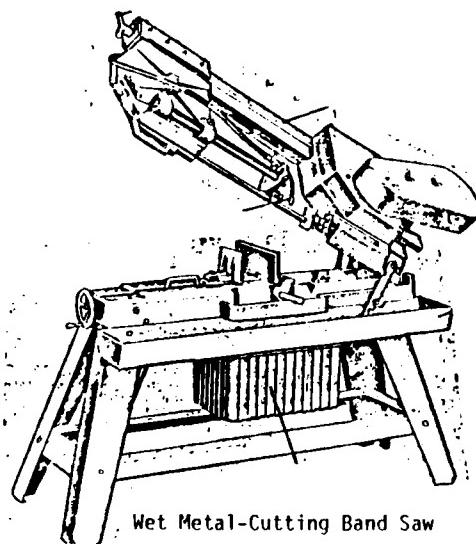
1A-3

TYPE:

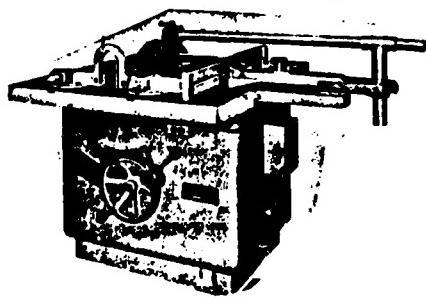
Maximum Dimensions: (4x4x8) Feet — Maximum Weight: 1,000 Pounds

EXAMPLES

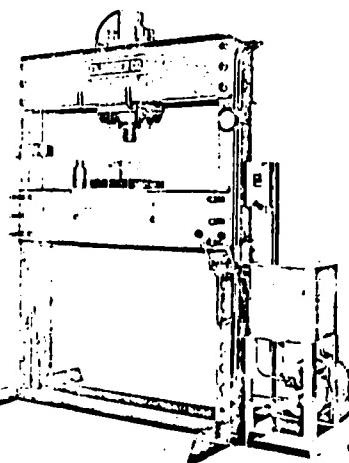
Light Drill Presses  
Band Saws  
Lathes  
Presses



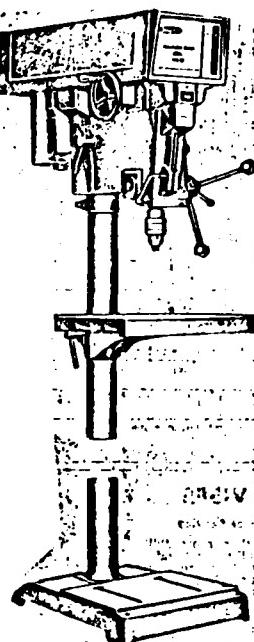
Wet Metal-Cutting Band Saw



Tilting Arbor Saw



Hydraulic Press



Drill Press

GROUP: 1A-3 MACHINE TOOLS/METAL & WOOD WORKING EQUIPMENT	DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION ( H/B ≤ 2 )	BLAST LEVEL (PSI)			RECOVERY	
		BLAST w/o MISSILES		MISSILES		
		SECURED	NOT SECURED	MANHOURS	DAYS	
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u> Damaged wiring, covers, work lights, guards; some controls inoperative		2	2	1.5	8	1
3. <u>Moderate to heavy damage:</u> Hand wheels and controls broken; motor damaged; some frame damage		6	4	3	40	10
4. <u>Destroyed:</u> Replacement required						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		4	3		4	1
VERTICAL CONFIGURATION ( H/B > 2 )						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u> (see above)		2	1.5	1.5	8	1
3. <u>Moderate to heavy damage:</u> (see above)		4	3	3	40	10
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		3	3		4	1

**PORTABLE ELECTRICAL EQUIPMENT, RUGGED**

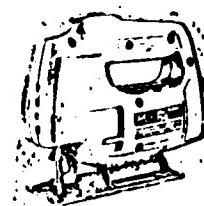
TYPE: Maximum Dimensions: (4x4x8) Feet — Maximum Weight: 1,000 Pounds EQUIPMENT PAGE NO. 1B-1

**EXAMPLES**

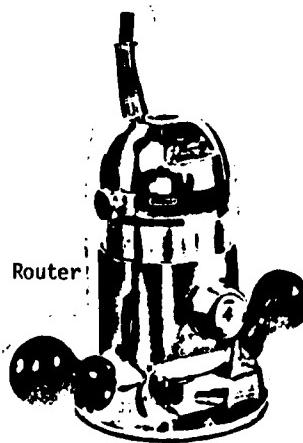
Power Hand Tools  
Welding Machines



Hand Drill



Jig Saw



Router

GROUP: 1B-1 PORTABLE ELECTRICAL EQUIPMENT, RUGGED	DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION ( H/B ≤ 2 )	BLAST LEVEL (PSI)			RECOVERY	
		BLAST w/o MISSILES		MISSILES		
		SECURED	NOT SECURED	MANHOURS	DAYS	
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u> Covers jam against components; plastic components break or shatter		5.0	3.0	3.0	4	1
3. <u>Moderate to heavy damage:</u> Covers short out electrical components; knobs, switches broken from missles and impact		10.0	5.0	5.0	8	1
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		8	4		2	< 1
VERTICAL CONFIGURATION ( H/B > 2 )						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>						
3. <u>Moderate to heavy damage:</u>						
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING						
PAGE 1B-1	PORTABLE ELECTRICAL EQUIPMENT					

**PANEL/RACK/MACHINE MOUNTED EQUIPMENT**

**TYPE:**

**EQUIPMENT PAGE NO.**

**1B-2**

**Maximum Dimensions: (4x4x8) Feet — Maximum Weight: 1,000 Pounds**

**EXAMPLES**

Flowmeters

Temperature Recorders

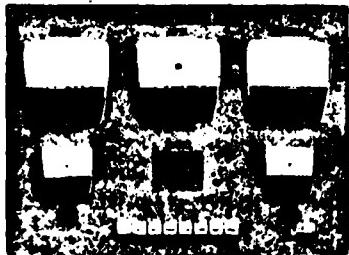
Meters

Gauges

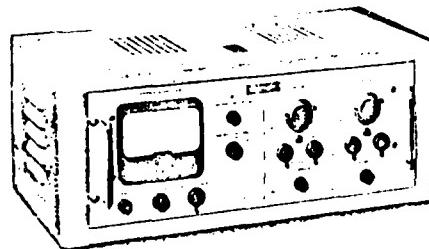
Amplifiers

Recorder/controller

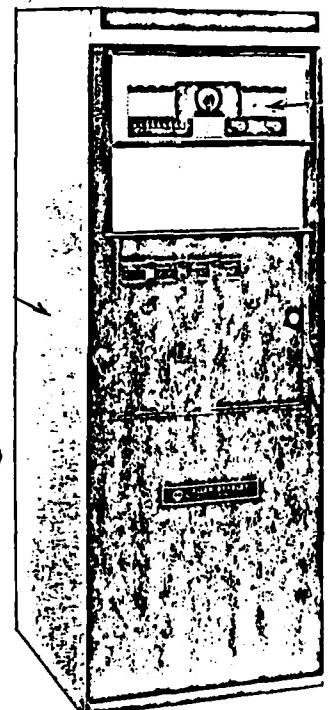
Arc Welders



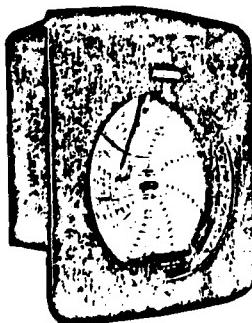
0-Type Current Meter System (Panel)



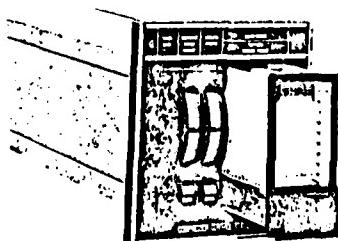
Two Channel Carrier Amplifier System



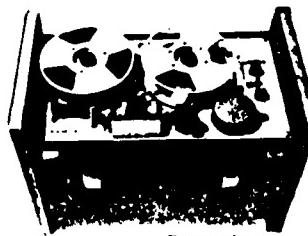
Allen-Bradley  
N/C Unit



Foxboro Pneumatic  
Recorder (Field Mounted)



Fisher Electronic  
Recorder (Panel Mounted)



Recorders

GROUP: 1B-2 PANEL/RACK/MACHINE MOUNTED EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
DAMAGE DESCRIPTION	SECURED	NOT SECURED			
HORIZONTAL CONFIGURATION ( H/B ≤ 2 )					
1. <u>Little or no damage:</u> Some meters damaged					
2. <u>Light to moderate damage:</u> Meters broken; Panels/covers bent; vacuum tubes broken	1	1	1	4	1
3. <u>Moderate to heavy damage:</u> Mechanical linkages damaged; controls broken; cathode ray tubes broken; front panels bent; covers jammed against internal components; panel/rack may overturn	3	2	2	8	2
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	2	2		2	< 1
VERTICAL CONFIGURATION ( H/B > 2 )					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	1	1	1	4	1
3. <u>Moderate to heavy damage:</u>	2	2	2	8	2
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	2	2		2	< 1
PAGE 1B-2	PANEL/RACK/MACHINE MOUNTED EQUIPMENT				

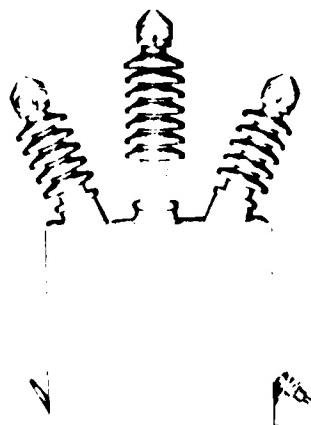
ELECTRICAL POWER DISTRIBUTION EQUIPMENT

EQUIPMENT PAGE NO. 1B-3

TYPE: Maximum Dimensions: (4x4x8) Feet — Maximum Weight: 1,000 Pounds

EXAMPLES

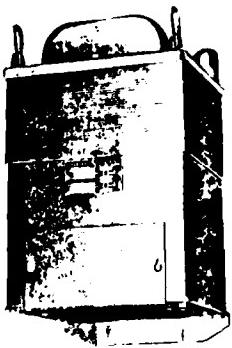
Starter/Disconnect  
Transformer  
Capacitors



Capacitors



Starter/Disconnect



Transformer

GROUP: 1B-3 ELECTRICAL POWER DISTRIBUTION EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	SECURED	NOT SECURED	MANHOURS	DAYS	
HORIZONTAL CONFIGURATION ( H/B ≤ 2 )					
1. <u>Little or no damage:</u> Panels/covers bent					
2. <u>Light to moderate damage:</u> Radiators on transformers bent and leaking; covers/panels blown against internal components; broken standoffs & mounts; plastic components broken.	2	2	1	24	4
3. <u>Moderate to heavy damage:</u> Cases/cans short out capacitors; insulators broken; wires torn from connections; oil-filled units leaking; piping damaged; controls broken	4	3	3	48	8
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3	3		3	< 1
VERTICAL CONFIGURATION ( H/B > 2 )					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	2	2	2	24	4
3. <u>Moderate to heavy damage:</u>	4	3	3	48	8
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3	3		4	< 1
PAGE 1B-3	ELECTRICAL POWER DISTRIBUTION EQUIPMENT				

**MOTORS**

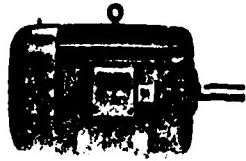
TYPE: \_\_\_\_\_ EQUIPMENT PAGE NO. 1B-4

Maximum Dimensions: (4x4x8) Feet — Maximum Weight: 1,000 Pounds

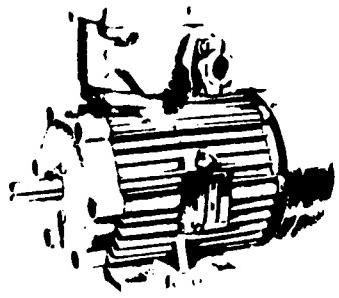
**EXAMPLES**

High Efficiency Motor

Hazardous Duty Motor



High Efficiency Motor



Hazardous Duty Motor

GROUP: 1B-4 MOTORS	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	INDUCTION (AC)	DC or SYNCHRONOUS			
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION ( H/B ≤ 2 )					
1. <u>Little or no damage:</u> Power connection covers bent; access panels deformed					
2. <u>Light to moderate damage:</u> Covers blown into splices and/or commutator (or slip ring) assemblies; some wiring pulled loose at terminations.	4	3	2	4	<1
3. <u>Moderate to heavy damage:</u> Motors mounts broken; windings damaged by missiles and deflecting covers; shaft misalignment.	8	6	4	6	<1
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	6	5		2	<1
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	6	6		2	<1

**PORTABLE PRESSURIZED BOTTLES AND CYLINDERS**

**TYPE:** Maximum Dimensions: (4x4x8) Feet

**Maximum Weight:** 1,000 Pounds

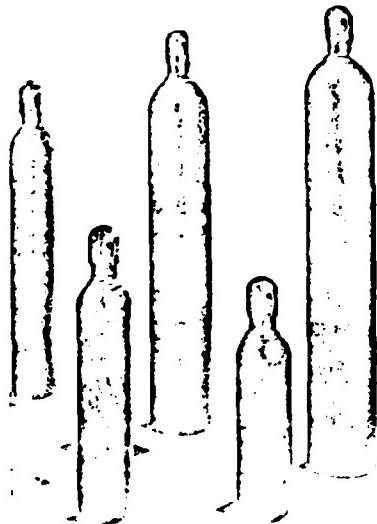
EQUIPMENT PAGE NO.

1D-1

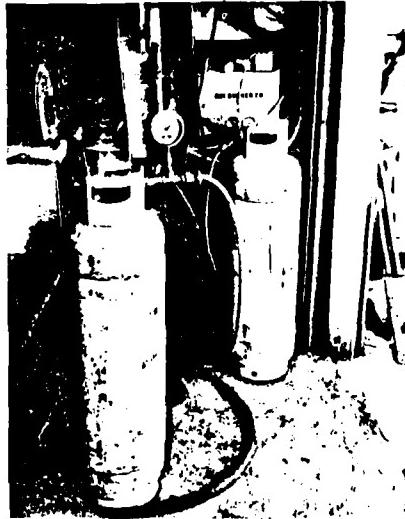
**EXAMPLES**

High Pressure Gas Bottles

Liquefied Gas Bottles



High Pressure Gas Cylinders



Gas Cylinders

GROUP: 1D-1 PORTABLE PRESSURE/HEAVY-WALLED VESSELS	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	SECURED	NOT SECURED	MANHOURS	DAYS	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION ( H/B ≤ 2 )					
1. <u>Little or no damage:</u> Regulators and light accessories damaged					
2. <u>Light to moderate damage:</u> Missiles dent sides & break light accessories; overturning	100	10	4	4	1
3. <u>Moderate to heavy damage:</u> Piping ruptured; major damage to accessories; leaks produced	200	20	8	8	1
4. <u>Destroyed:</u> Container unusable for pressures					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	150	15		1	< 1
VERTICAL CONFIGURATION ( H/B > 2 )					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	100	10	4	4	1
3. <u>Moderate to heavy damage:</u>	200	20	8	8	1
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	150	15		1	< 1
PAGE 1D-1	PORTABLE PRESSURE/HEAVY-WALLED VESSELS				

TYPE: FIXED HEAVY-WALLED VESSELS

EQUIPMENT PAGE NO. 1D-2

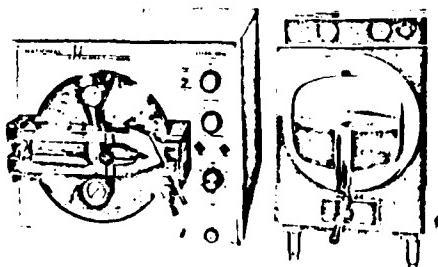
Maximum Dimensions: (4x4x8) Feet — Maximum Weight: 1,000 Pounds

EXAMPLES

Cook Kettles

Autoclaves

Mixers



Autoclave/Dryer



Mixer/Muller



Steam Jacketed Kettle

GROUP: 1D-2 FIXED HEAVY-WALLED VESSELS	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	SECURED		MANHOURS	DAYS	
HORIZONTAL CONFIGURATION ( H/B ≤ 2 )					
1. <u>Little or no damage:</u> Light accessory damage					
2. <u>Light to moderate damage:</u> Accessories damaged; covers deformed	2		2	8	1
3. <u>Moderate to heavy damage:</u> Loose components blown off; denting of walls evident; displaced off mountings; pressure seals & surfaces heavily damaged; controls destroyed	4		4	12	2
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3			2	1
VERTICAL CONFIGURATION ( H/B > 2 )					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	2		2	8	1
3. <u>Moderate to heavy damage:</u>	4		3	12	2
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3		3	2	1

**VULNERABILITY RATINGS**

**GROUP 2**

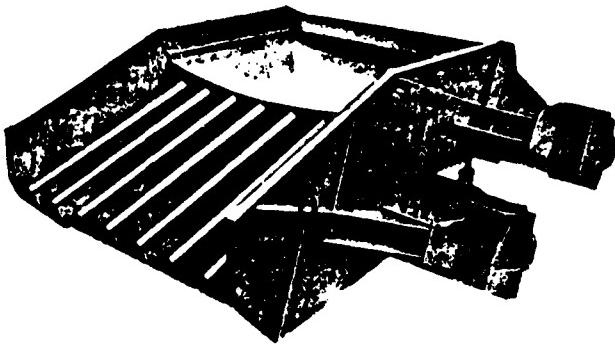
TYPE: LIGHT FRAME MACHINERY/MECHANICAL EQUIPMENT

EQUIPMENT PAGE NO. 2A-1

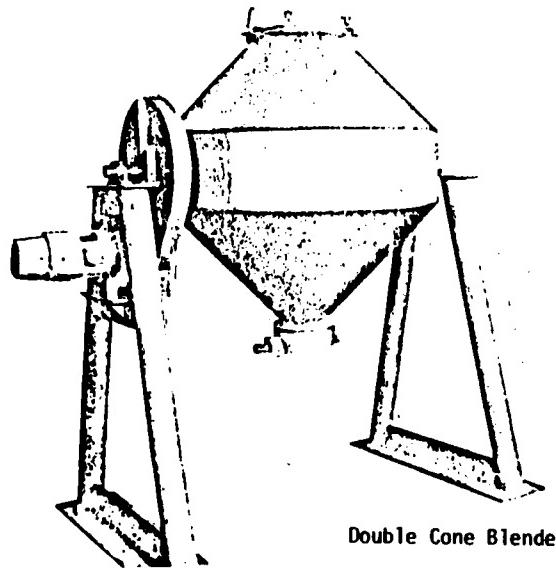
Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

EXAMPLES

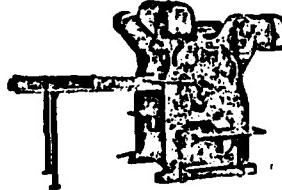
Separators  
Sifters  
Classifiers  
Screw Mixers  
Light Commercial Printing Press  
Feeders



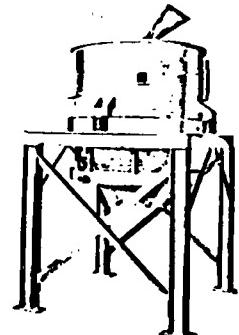
Grizzly Feeder



Double Cone Blender



Two-Color Printing Press



Coolant Separator

GROUP: 2A-1 LIGHT FRAME MACHINERY/MECHANICAL EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	SECURED	NOT SECURED	MANHOURS	DAYS	
<b>DAMAGE DESCRIPTION</b>					
<b>HORIZONTAL CONFIGURATION ( H/B ≤ 2 )</b>					
1. <u>Little or no damage:</u> Some accessories damaged; Panels & covers bent					
2. <u>Light to moderate damage:</u> Panels & covers buckled and torn off; breakables fractured; internal components misaligned; controls damaged	2	1.5	1.5	16	3
3. <u>Moderate to heavy damage:</u> Unit displaced on frame; internal components damaged; frames & supports damaged; covers driven into internal components; controls destroyed	3	2	2	32	8
4. <u>Destroyed:</u>					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>					
<b>VERTICAL CONFIGURATION ( H/B &gt; 2 )</b>					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	2	1	1	16	3
3. <u>Moderate to heavy damage:</u>	3	1.5	1.5	32	8
4. <u>Destroyed:</u>					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>					
PAGE 2A-1	LIGHT FRAME MACHINERY/MECHANICAL EQUIPMENT				

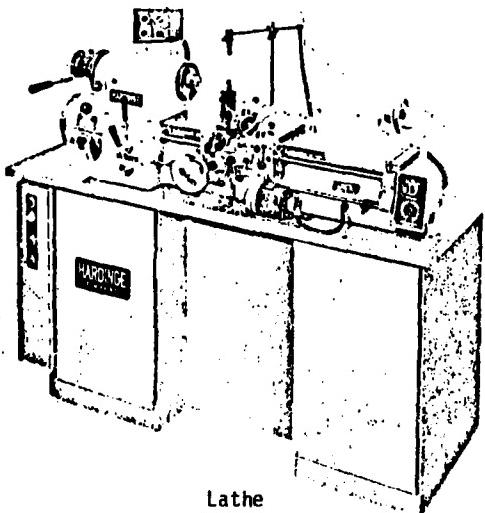
**HEAVY FRAME MACHINERY/MECHANICAL EQUIPMENT**

EQUIPMENT PAGE NO.

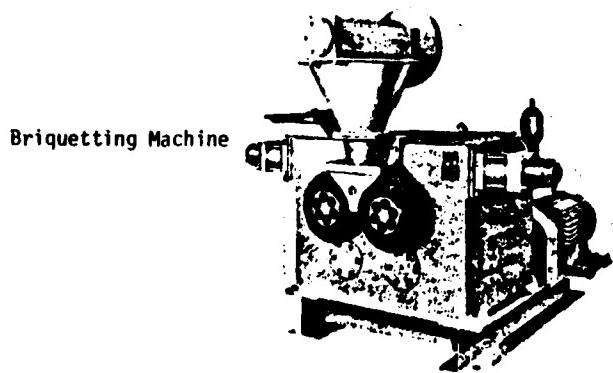
2A-2

TYPE:

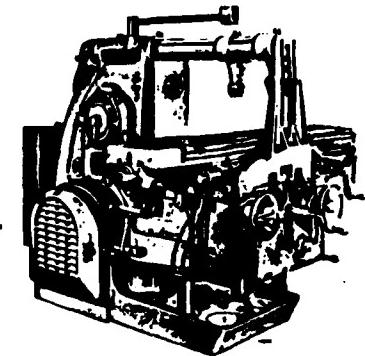
Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds



Lathe



Briquetting Machine



Horizontal Milling Machine

**EXAMPLES**

Injection Molding Presses  
Extruders  
Forges  
Milling Machines  
Casting Machines

GROUP: 2A-2 HEAVY FRAME MACHINERY/MECHANICAL EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	SECURED	NOT SECURED	MANHOURS	DAYS	
<b>DAMAGE DESCRIPTION</b> <b>HORIZONTAL CONFIGURATION ( H/B ≤ 2 )</b>					
1. <u>Little or no damage:</u> Covers and guards bent					
2. <u>Light to moderate damage:</u> Covers damaged & torn off; wiring & light piping torn loose; exposed breakables fractured; electrical controls damaged; instrumentation broken; loose items blown off.	4	3	3	12	2
3. <u>Moderate to heavy damage:</u> Instruments destroyed; motors heavily damaged & misaligned; heavy piping torn loose; wiring torn loose; controls badly damaged; misalignment of major components; some frame damage	8	4	6	24	4
4. <u>Destroyed:</u>					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>	6	4		4	< 1
<b>VERTICAL CONFIGURATION ( H/B &gt; 2 )</b>					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	3	3	2	16	2 - 3
3. <u>Moderate to heavy damage:</u>	6	4	5	32	5
4. <u>Destroyed:</u>					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>	5	4		4	< 1

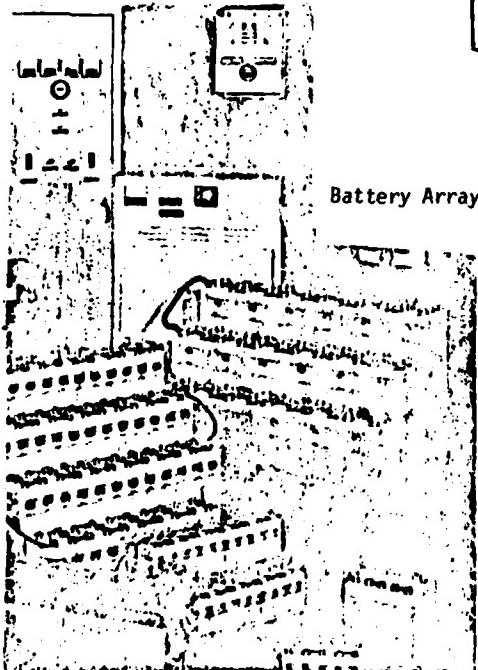
**ELECTRICAL GENERATING EQUIPMENT**

**TYPE:** Maximum Dimensions: (15x15x20) Feet      **EQUIPMENT PAGE NO.** 2B-1

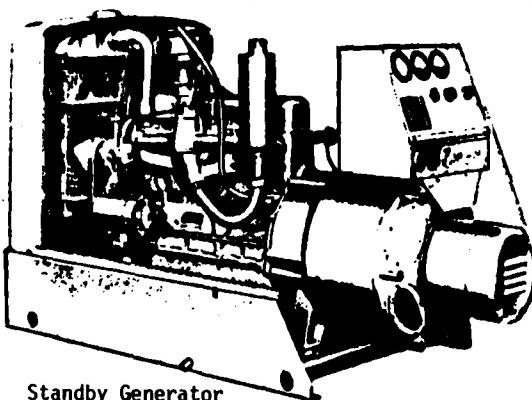
Maximum Weight: 30,000 Pounds

**EXAMPLES**

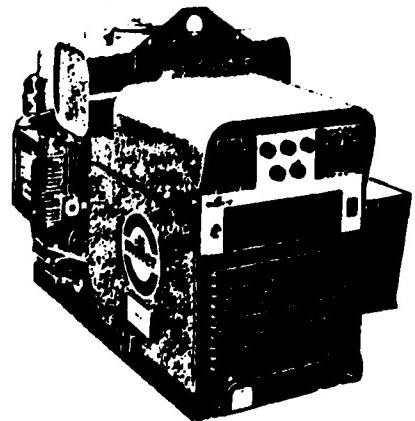
Emergency or Standby Units  
Cogeneration Systems  
Battery Arrays



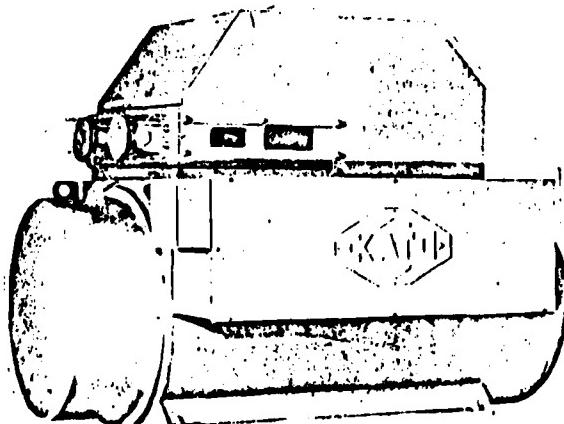
Battery Arrays



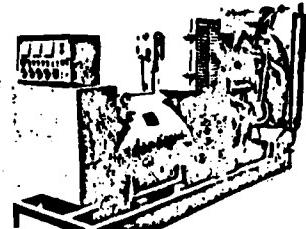
Standby Generator



Standby Power Unit



Heavy Duty AC Generator



Diesel Electric Generator

GROUP: 2B-1 ELECTRICAL GENERATING EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	SECURED	NOT SECURED	MANHOURS	DAYS	
HORIZONTAL CONFIGURATION ( H/B ≤ 2)					
1. <u>Little or no damage:</u> Thin or light covers bent					
2. <u>Light to moderate damage:</u> Radiators on emergency power units damaged & leaking; instrumentation damaged; plate rectifiers damaged; some light control damaged	1.5		1	8	1
3. <u>Moderate to heavy damage:</u> Solid state components damaged by missiles; engines & generators displaced; motors damaged; controls broken; accessories heavily damaged	3		2	16	3
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	2			3	< 1
VERTICAL CONFIGURATION ( H/B > 2)					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>					
3. <u>Moderate to heavy damage:</u>					
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING					
PAGE 2B-1	ELECTRICAL GENERATING EQUIPMENT				

TYPE: ELECTRICAL/ELECTRONIC PANELS & RACKS

EQUIPMENT PAGE NO. 2B-2

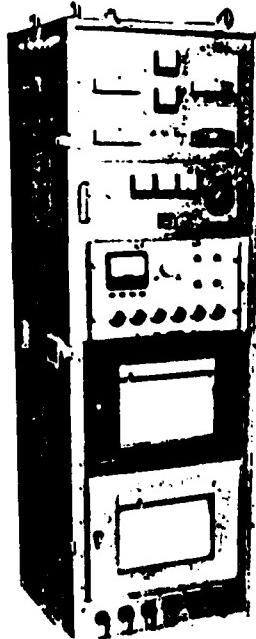
Maximum Dimensions: (15x15x20) Feet - Maximum Weight: 30,000 Pounds

EXAMPLES

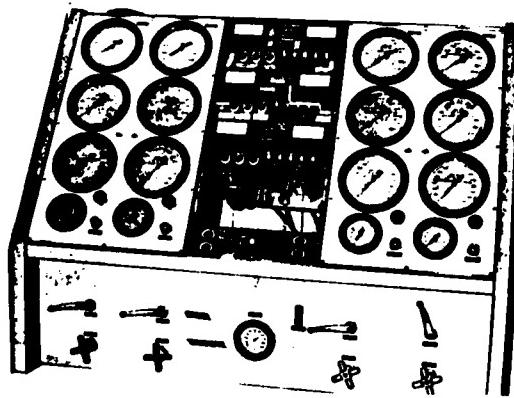
Control Panels

Instrumentation Panels

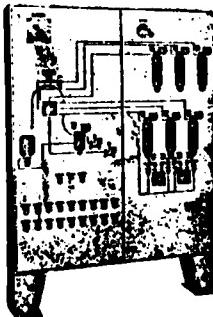
Instrumentation Racks



Instrumentation Rack



Instrumentation Panel



Control Panel

GROUP: 2B-2 ELECTRICAL/ELECTRONIC PANELS & RACKS	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	SECURED	NOT SECURED	MANHOURS	DAYS	
<b>DAMAGE DESCRIPTION</b> <b>HORIZONTAL CONFIGURATION ( H/B ≤ 2 )</b>					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u> Meter movements broken; cover glasses broken; metal covers/panels bent; instruments decalibrated.	2	1	1	16	2
3. <u>Moderate to heavy damage:</u> Faces of panels bent/buckled with corresponding damage to elec. components; controls broken; covers & cases pushed into elec. components; breakables fractured; circuit boards cracked/broken.	4	2	2	24	4
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3	2		3	< 1
<b>VERTICAL CONFIGURATION ( H/B &gt; 2 )</b>					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	1	1	1		
3. <u>Moderate to heavy damage:</u>	3	2	2		
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	2	2			

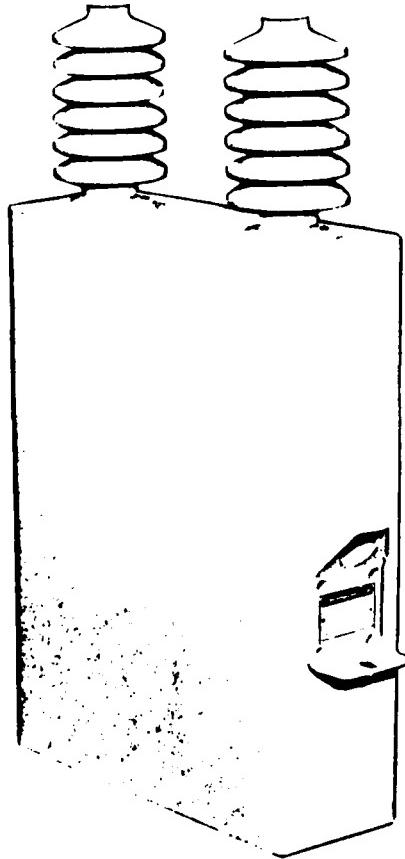
**ELECTRICAL POWER EQUIPMENT**

EQUIPMENT PAGE NO.

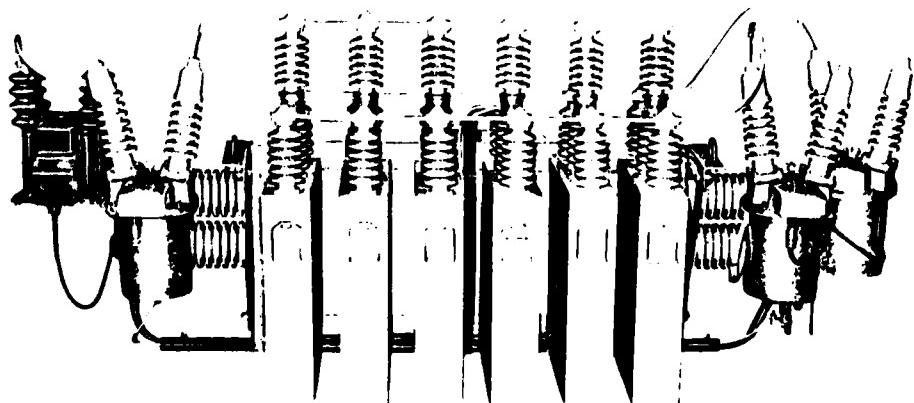
2B-3

TYPE: \_\_\_\_\_  
Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

**EXAMPLES**  
Capacitors  
Transformer  
Switchgear



Capacitor Unit



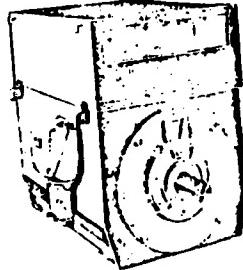
Capacitor Array

GROUP: 2B-3 ELECTRICAL POWER EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	SECURED	NOT SECURED	MANHOURS	DAYS	
<b>DAMAGE DESCRIPTION</b> <b>HORIZONTAL CONFIGURATION ( H/B ≤ 2 )</b>					
1. <u>Little or no damage:</u> Distortion of radiators, cover plates.	3	2	2	8	1
2. <u>Light to moderate damage:</u> Cooling radiators deformed & leaking; some insulators broken; wiring damaged.	6	3	4	16	3
3. <u>Moderate to heavy damage:</u> Insulators broken; cases damaged; switch gear heavily damaged by missiles & displaced covers and components; units displaced from foundations.					
4. <u>Destroyed:</u>					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>	5	3		3	< 1
<b>VERTICAL CONFIGURATION ( H/B &gt; 2 )</b>					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	3	2	2	10	2
3. <u>Moderate to heavy damage:</u>	4	4	3	24	3
4. <u>Destroyed:</u>					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>	4	3		3	< 1

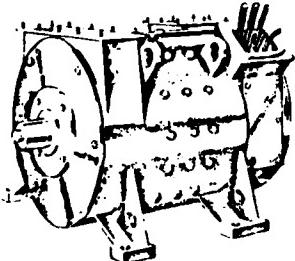
**MOTORS**

EQUIPMENT PAGE NO. 2B-4

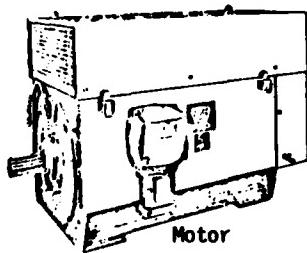
TYPE: Maximum Dimensions: (15x15x20) Feet - Maximum Weight: 30,000 Pounds



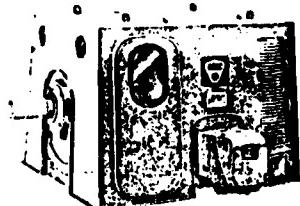
Motor



Motor



Motor



Motor

GROUP: 2B-4 MOTORS	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES	MISSILES	MANHOURS		
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION ( H/B ≤ 2 )	SECURED	UNSECURED			
1. <u>Little or no damage:</u> Power connection covers bent; access panels deformed					
2. <u>Light to moderate damage:</u> Covers blown into splices and/or commutator (or slip ring) assemblies; some wiring pulled loose at terminations.	4	3	2	16	4
3. <u>Moderate to heavy damage:</u> Motors mounts broken; windings damaged by missiles and deflecting covers; shaft misalignment.	8	6	4	40	6
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	6	5		2	< 1
VERTICAL CONFIGURATION ( H/B > 2 )					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	3	2	2	20	4
3. <u>Moderate to heavy damage:</u>	8	4	4	48	8
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	6	3		2	< 1

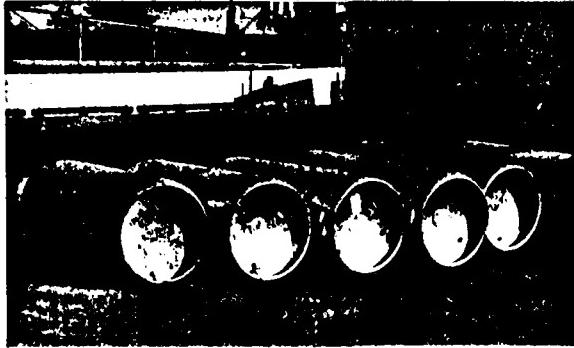
**MOVABLE HEAVY-WALLED/PRESSURE VESSELS**

EQUIPMENT PAGE NO. 2D-1

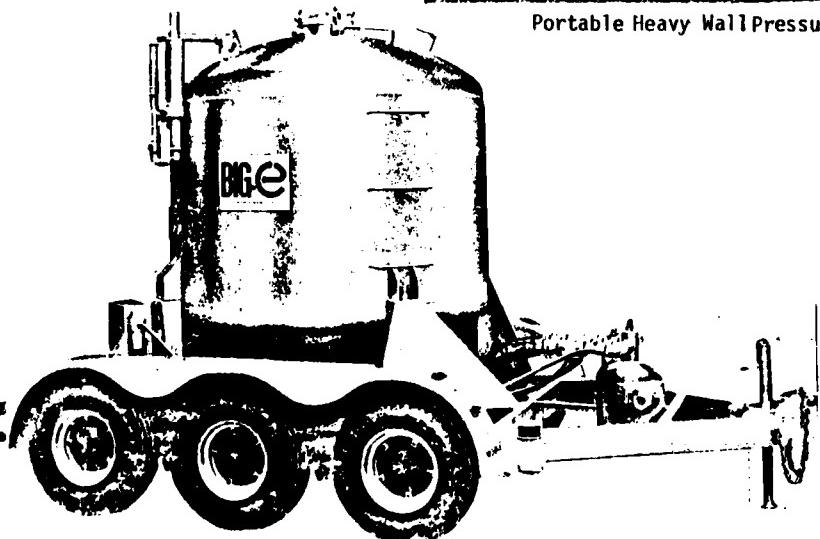
TYPE: Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

EXAMPLES

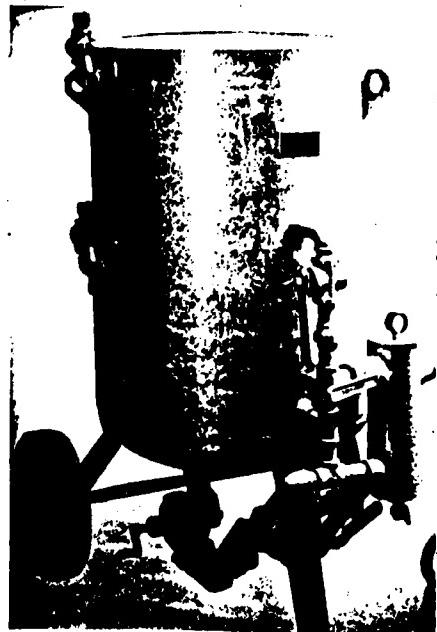
- Transfer Tanks
- LPG Trucks
- Production Blasters
- Pressure Vessels



Portable Heavy Wall Pressure Vessel



Production Blaster



Mobile Sand Blaster

GROUP: 2D-1 MOVABLE HEAVY-WALLED/PRESSURE VESSELS	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	SECURED	NOT SECURED	MANHOURS	DAYS	
HORIZONTAL CONFIGURATION ( H/B ≤ 2 )					
1. <u>Little or no damage:</u> Light accessory damage					
2. <u>Light to moderate damage:</u> Moderate accessory damage; some controls bent; light piping leaks at connections; tires punctured by missiles	2	1	1	8	1
3. <u>Moderate to heavy damage:</u> Heavy damage to pipe connections and controls; extensive leaking of vessel	4	2	2	16	2
4. <u>Destroyed:</u> Heavy damage to peripherals & accessories result in loss of structural integrity. Tank unsafe					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3	2		2	< 1
VERTICAL CONFIGURATION ( H/B > 2 )					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>					
3. <u>Moderate to heavy damage:</u>					
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING					
PAGE 2D-1	MOVABLE HEAVY-WALLED/PRESSURE VESSELS				

TYPE: STATIONARY HEAVY-WALLED/PRESSURE VESSELS

EQUIPMENT PAGE NO.

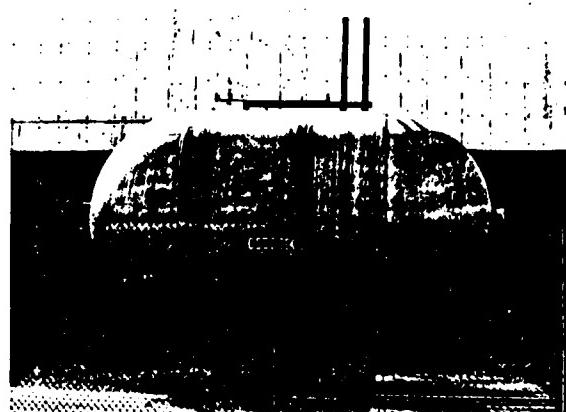
2D-2

Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

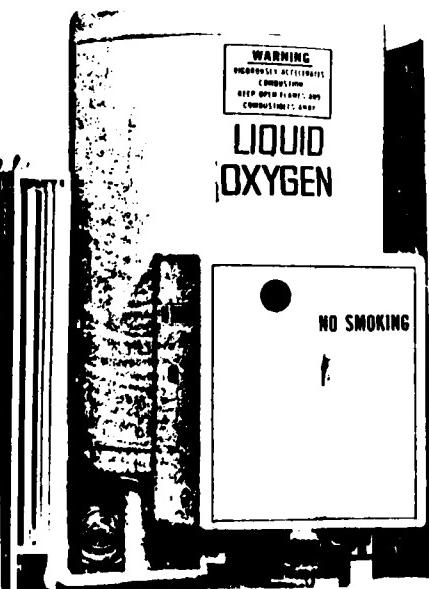
EXAMPLES

LPG Tank

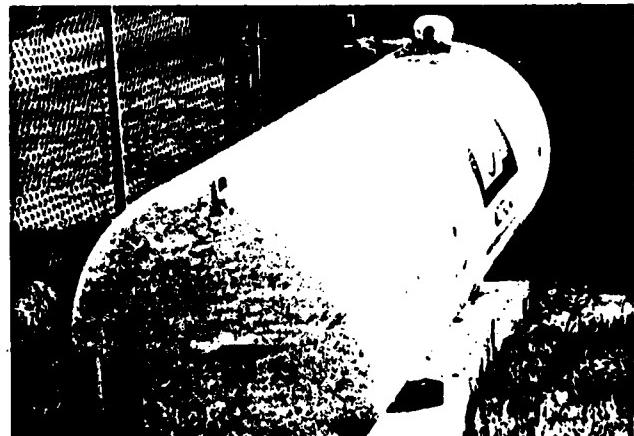
Gas Pressure Vessel



LPG Tanks



Gas Pressure Vessel



GROUP: 2D-2 STATIONARY HEAVY-WALLED/PRESSURE VESSELS	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	FULL	EMPTY	MANHOURS	DAYS	
<b>DAMAGE DESCRIPTION</b>					
<b>HORIZONTAL CONFIGURATION ( H/B ≤ 2 )</b>					
1. <u>Little or no damage:</u> Light accessories damaged					
2. <u>Light to moderate damage:</u> Light piping bent and leaking at connections; panels & covers bent/buckled or blown off; controls damaged; field-mounted instrumentation smashed.	4	3	2	20	3
3. <u>Moderate to heavy damage:</u> Very heavy accessory damage; major piping deformation with leaks; structural damage to supports; anchors fail; unit displaced on foundations.	8	6	4	120	20
4. <u>Destroyed:</u> Pressure vessel unsafe					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>					
<b>VERTICAL CONFIGURATION ( H/B &gt; 2 )</b>					
1. <u>Little or no damage:</u> (see above)					
2. <u>Light to moderate damage:</u> (see above)	3	2	2	20	3
3. <u>Moderate to heavy damage:</u> (see above)	6	5	4	120	20
4. <u>Destroyed:</u>					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>					

**HEAVY-WALLED PROCESSING VESSELS**

EQUIPMENT PAGE NO.

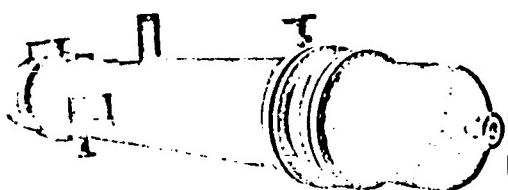
2D-3

TYPE:

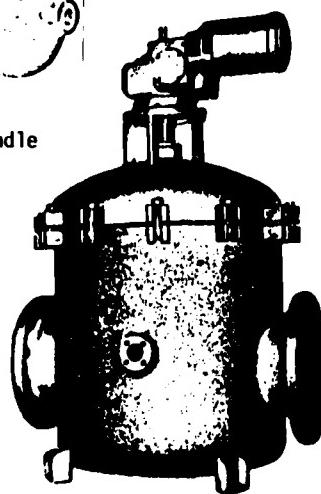
Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

EXAMPLES

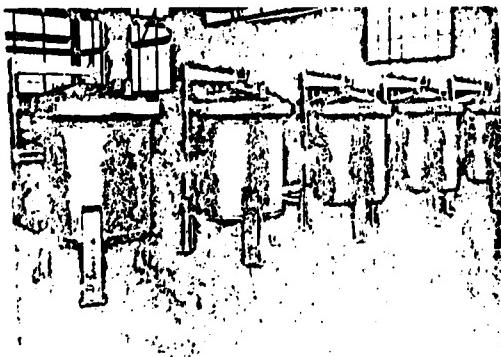
Autoclaves  
Reactors  
Strainers



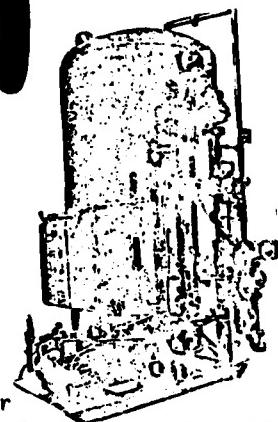
Heat Exchangers with Removable Bundle



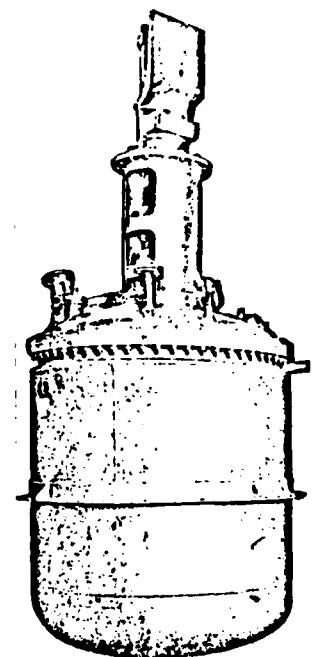
High Pressure Strainer



Vertical Lift Autoclaves 48" Diameter



Demineralizer



Autoclave for Low Pressure Synthesis

GROUP: 2D-3 HEAVY-WALLED PROCESSING VESSELS	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	FULL	EMPTY	MANHOURS	DAYS	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION ( H/B ≤ 2)					
1. <u>Little or no damage:</u> Light instrumentation damage					
2. <u>Light to moderate damage:</u> Light components heavily damaged; piping damaged and leaking at connections	3	2	2	8	1
3. <u>Moderate to heavy damage:</u> Heavy piping & accessory damage; frame/supports distorted; unit displaced from foundation.	6	5	4	16	3
4. <u>Destroyed:</u> Vessel unsafe/unusable					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	5	3		3	< 1
VERTICAL CONFIGURATION ( H/B > 2)					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	3	2	2	10	2
3. <u>Moderate to heavy damage:</u>	5	4	4	24	4
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	4	3		4	< 1
PAGE 2D-3	HEAVY-WALLED PROCESSING VESSELS				

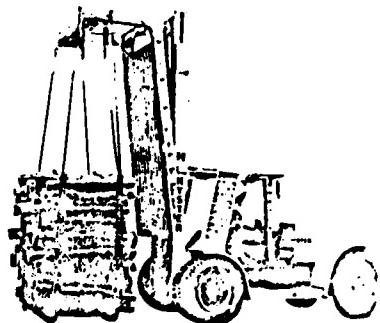
TYPE: MOBILE MECHANICAL HANDLING EQUIPMENT (POTENTIAL RESOURCE) EQUIPMENT PAGE NO. 2E-1  
Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds



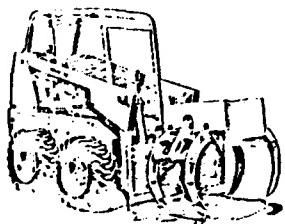
Forklift

EXAMPLES

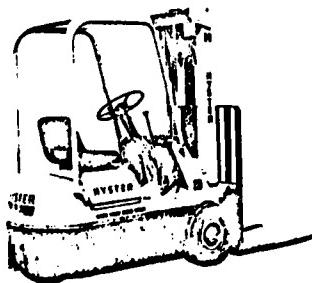
Loaders  
Forklifts



Pulpwood Loader



Loader



Lift Trucks



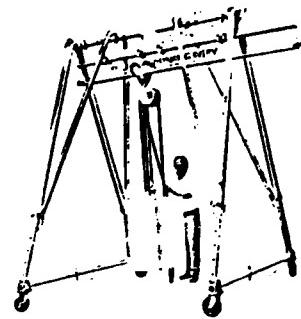
Forklift

GROUP: 2E-1 MOBILE MECHANICAL HANDLING EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	SECURED	NOT SECURED	MANHOURS	DAYS	
<b>DAMAGE DESCRIPTION</b>					
<b>HORIZONTAL CONFIGURATION ( H/B ≤ 2 )</b>					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u> Controls damaged; covers & panels dented and/or blown off; unprotected accessories damaged by deflecting covers/missiles	3	2	2	8	1
3. <u>Moderate to heavy damage:</u> Tires punctured by missiles; heavy blast damage to flat surfaces; glass broken; heavy control damage; breakables fractured; engine accessories damaged/broken	5	3	3	16	3
4. <u>Destroyed:</u>					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>					
<b>VERTICAL CONFIGURATION ( H/B &gt; 2 )</b>					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>					
3. <u>Moderate to heavy damage:</u>					
4. <u>Destroyed:</u>					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>					
PAGE 2E-1	MOBILE MECHANICAL HANDLING EQUIPMENT				

TYPE: MOVABLE/LIMITED/TRACKED HANDLING EQUIPMENT EQUIPMENT PAGE NO. 2E-2  
Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

EXAMPLES

Bridge Cranes  
Monorail Cranes  
Balance Arms



Gantry

GROUP:	DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION ( H/B ≤ 2 )	BLAST LEVEL (PSI)			RECOVERY	
		BLAST w/o MISSILES		MISSILES		
		SECURED	NOT SECURED	MANHOURS	DAYS	
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u> Covers & panels bent/buckled and/or torn off; electrical components broken; wiring damaged		3	2	2	6	1
3. <u>Moderate to heavy damage:</u> Equipment off tracks; motors demounted/misaligned; piping broken at connections; some structural damage; some castings broken		5	4	3	24	2
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		4	3		8	1
VERTICAL CONFIGURATION ( H/B > 2 )						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>		2	2	2	8	1
3. <u>Moderate to heavy damage:</u>		4	3	3	32	4
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		3	3		8	1

**TYPE: STATIONARY MATERIAL HANDLING EQUIPMENT**

EQUIPMENT PAGE NO.

2E-3

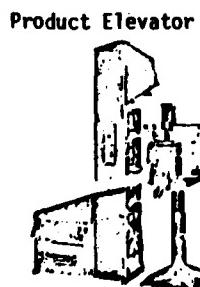
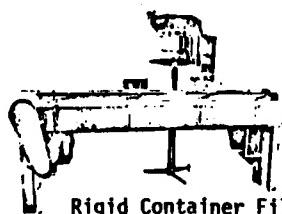
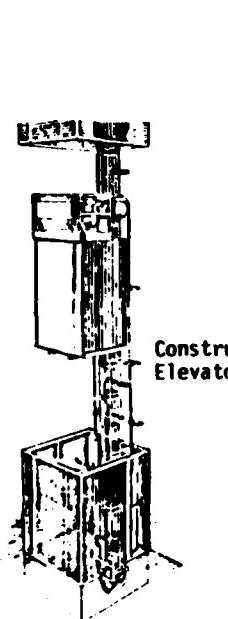
Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

**EXAMPLES**

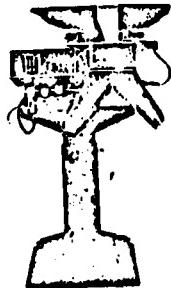
Conveyors

Can/Bottle Handlers and Fillers

Material Elevators



Shaker Conveyor



Counter Feeder



Form, Fill, Seal,  
Bag Machine

GROUP: 2E-3 STATIONARY MATERIAL HANDLING EQUIPMENT	DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION ( H/B ≤ 2 )	BLAST LEVEL (PSI)			RECOVERY	
		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u> Covers & plates & panels bent or buckled; misalignment of light frame members; breakable components fractured; wiring damaged		2	1	2	8	1
3. <u>Moderate to heavy damage:</u> Motors and drives misaligned; light frame members heavily damaged; extensive control damage; electrical components very heavily damaged; units displaced on foundations.		6	3	4	16	2
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		4	2		8	1
VERTICAL CONFIGURATION ( H/B > 2 )						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>		2	1	2	8	1
3. <u>Moderate to heavy damage:</u>		4	3	4	16	2
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		3	2		8	1

**SIMPLE REFRACTORY CONSTRUCTIONS**

TYPE:

Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

EQUIPMENT PAGE NO.

2F-1

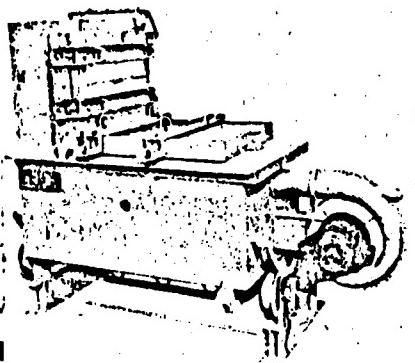
**EXAMPLES**

Box Type Furnaces

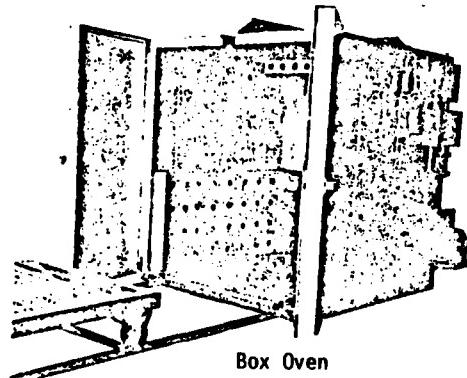
Ovens



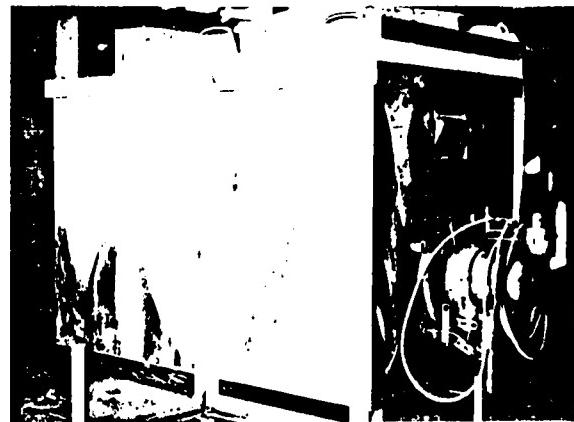
Box Oven



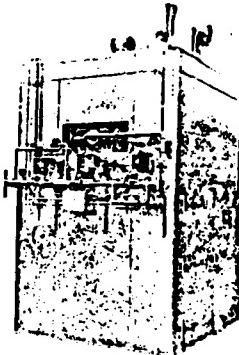
Reverberatory Furnace



Box Oven



Box Oven



Preheating Oven

GROUP: 2F-1 SIMPLE REFRACTORY CONSTRUCTIONS	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	MANHOURS	DAYS			
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION ( H/B ≤ 2 )					
1. <u>Little or no damage:</u> Light cracking					
2. <u>Light to moderate damage:</u> Some cracking and brick loss	1.5		1.5	8	1
3. <u>Moderate to heavy damage:</u> Heavy cracking and refractory damage; some walls fail; doors & access assemblies damaged; accessories damaged; instrumentation broken	3		2	16	2
4. <u>Destroyed:</u> Structure destroyed or unsafe					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	2			4	1
VERTICAL CONFIGURATION ( H/B > 2 )					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	1		1	12	1
3. <u>Moderate to heavy damage:</u>	2		2	24	2
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	2			4	1

TYPE: REFRACTORY LINED EQUIPMENT

EQUIPMENT PAGE NO.

2F-2

Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds



STEEL SHELL FURNACE

EXAMPLES

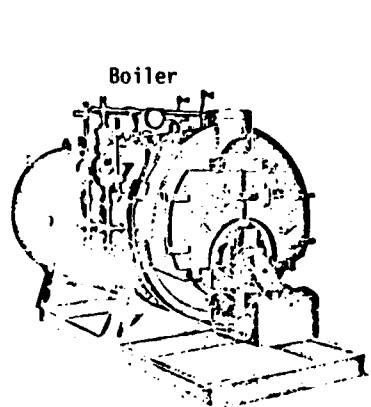
Boilers

Arc and Induction Furnaces

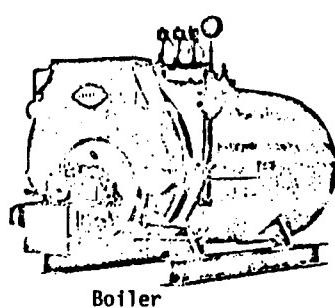
Stacks to 30 ft

Small Calciners

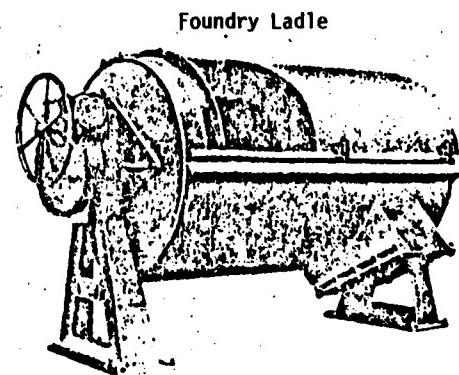
Ladles



Boiler



Boiler



Foundry Ladle

GROUP: 2F-2	REFRACTORY-LINED EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY						
		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS					
SECURED	NOT SECURED										
<b>DAMAGE DESCRIPTION</b>											
<b>HORIZONTAL CONFIGURATION ( H/B ≤ 2 )</b>											
1. <u>Little or no damage:</u> Some refractory cracking											
2. <u>Light to moderate damage:</u> Unprotected or unbacked refractory heavily damaged; other refractory cracked; accessories damaged; panels & covers damage components	2	1	2		8	1					
3. <u>Moderate to heavy damage:</u> Refractory lining needs extensive repair or replacement	4	2	3		48	3					
4. <u>Destroyed:</u>											
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>											
<b>VERTICAL CONFIGURATION ( H/B &gt; 2 )</b>											
1. <u>Little or no damage:</u>											
2. <u>Light to moderate damage:</u>	2	1	1		12	1					
3. <u>Moderate to heavy damage:</u>	3	2	2		48	3					
4. <u>Destroyed:</u>											
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>											

VULNERABILITY RATINGS

GROUP 3

**TYPE: ASSEMBLIES AND LIGHT FRAME CONSTRUCTIONS**

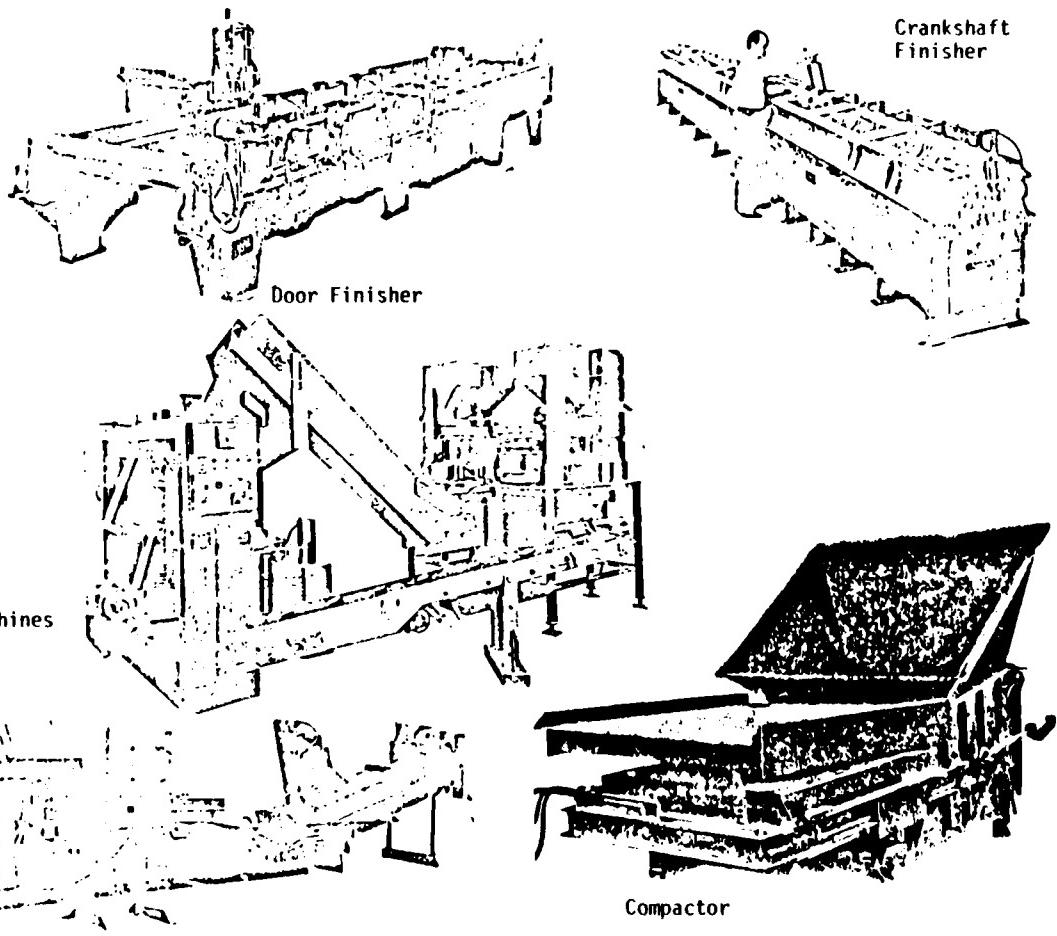
EQUIPMENT PAGE NO.

3A-1

**Minimum Dimensions: (15x15x20) Feet → Minimum Weight: 30,000 Pounds**

**EXAMPLES**

Printing Presses  
Looms  
Compactor



GROUP: 3A-1 ASSEMBLIES AND LIGHT FRAME CONSTRUCTIONS		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION		BLAST w/o MISSILES		MISSILES	RECOVERY	
	SECURED	NOT SECURED	MANHOURS		DAYS	
HORIZONTAL CONFIGURATION ( H/B ≤ 2 )						
1. <u>Little or no damage:</u> Covers bent; some wiring damage & broken glass	3	2	2		32	4
2. <u>Light to moderate damage:</u> Covers and panels wrecked; wiring and small piping damaged; controls & instrumentation smashed; breakables fractured						
3. <u>Moderate to heavy damage:</u> Motors damaged & misaligned; frame damaged; electrical components heavily damaged; piping and wiring torn off.	5	4	3		160	15
4. <u>Destroyed:</u> Replacement required						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	4	3			4	1
VERTICAL CONFIGURATION ( H/B > 2 )						
1. <u>Little or no damage:</u> (see above)						
2. <u>Light to moderate damage:</u> (see above)	2	2	2		32	5
3. <u>Moderate to heavy damage:</u> (see above)	5	4	3		240	24
4. <u>Destroyed:</u> (see above)						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	4	3			4	1

**HEAVY FRAME EQUIPMENT**  
TYPE: Minimum Dimensions : (15x15x20) Feet — Minimum Weight: 30,000 Pounds

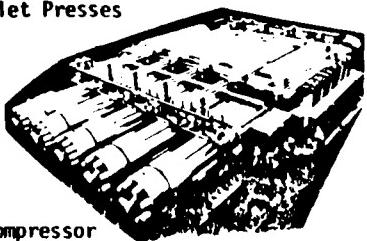
EQUIPMENT PAGE NO. 3A-2

**EXAMPLES**

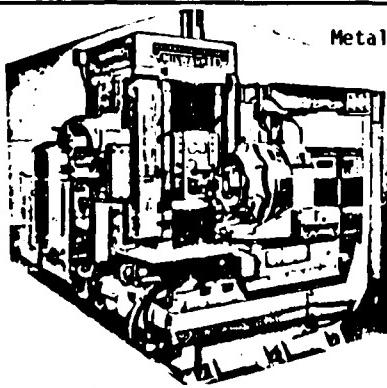
Large Presses

Large Forges

Slab/Billet Presses



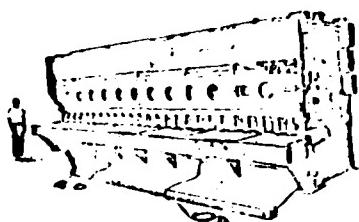
High Pressure Compressor



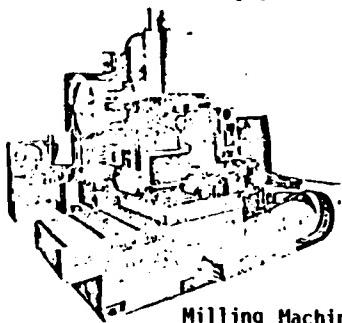
Metal Turning Center



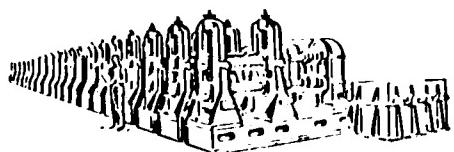
Plastic Molding Machine



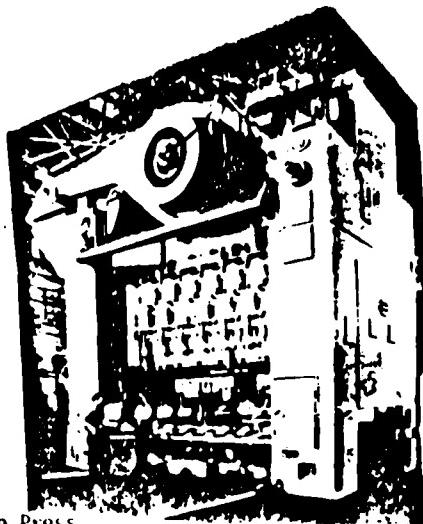
Heavy Shear



Milling Machine



Heavy Duty Roll Forming Machine



Stamp Press

GROUP: 3A-2 HEAVY FRAME EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	SECURED	NOT SECURED	MANHOURS	DAYS	
<b>DAMAGE DESCRIPTION</b> <b>HORIZONTAL CONFIGURATION ( H/B ≤ 2 )</b>					
1. <u>Little or no damage:</u> Covers bent; light accessories damaged					
2. <u>Light to moderate damage:</u> Covers torn off; wiring damaged; some control and accessory damage; instruments heavily damaged.	3	2	2	32	2
3. <u>Moderate to heavy damage:</u> Instruments destroyed; controls and accessories heavily damaged; some frame damage; piping torn loose.	8	4	3	60	4
4. <u>Destroyed:</u> Replacement necessary					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>	6	3		3	1
<b>VERTICAL CONFIGURATION ( H/B &gt; 2 )</b>					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	4	2	2	36	3
3. <u>Moderate to heavy damage:</u>	6	3	3	72	6
4. <u>Destroyed:</u>					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>	5	3		4	1
PAGE 3A-2	HEAVY FRAME EQUIPMENT				

TYPE: POWER GENERATION EQUIPMENT

EQUIPMENT PAGE NO. 3B-1

Minimum Dimensions: (15x15x20) Feet - Minimum Weight: 30,000 Pounds



GROUP: 3B-1 POWER GENERATION EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
DAMAGE DESCRIPTION	SECURED	NOT SECURED			
<b>HORIZONTAL CONFIGURATION ( H/B ≤ 2 )</b>					
1. <u>Little or no damage:</u> Covers bent/blown off; Gauges broken					
2. <u>Light to moderate damage:</u> Covers and guards blown into wiring; plastic components broken; instruments and uncovered accessories damaged	6	5	4	12	3
3. <u>Moderate to heavy damage:</u> Exposed conduits torn from terminations; wiring heavily damaged; some frame damage may occur.	12	8	6	120	10
4. <u>Destroyed:</u> Replacement necessary					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>					
<b>VERTICAL CONFIGURATION ( H/B &gt; 2 )</b>					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	4	4	4	16	3
3. <u>Moderate to heavy damage:</u>	8	6	6	120	10
4. <u>Destroyed:</u>					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>					
PAGE 3B-1	POWER GENERATION EQUIPMENT				

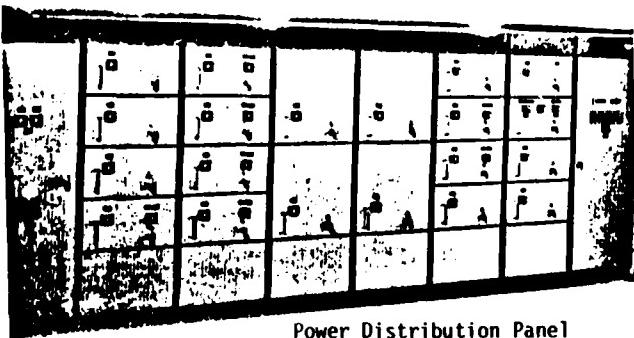
TYPE: HEAVY FRAMED RACKS, PANEL, ENCLOSED  
Minimum Dimensions; (15x15x20) Feet — Minimum Weight; 30,000 Pounds

EQUIPMENT PAGE NO.

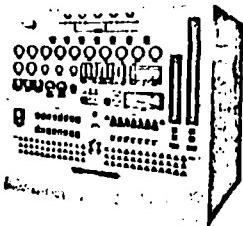
3B-2

EXAMPLES

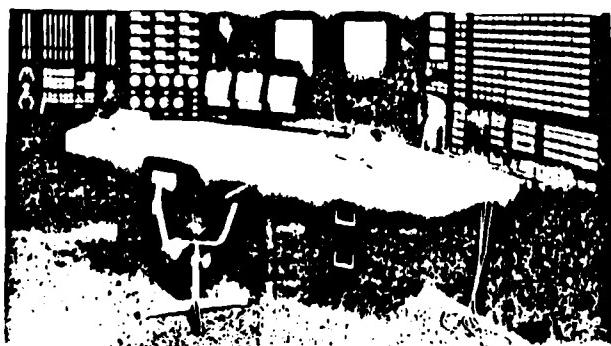
Main Distribution Panels



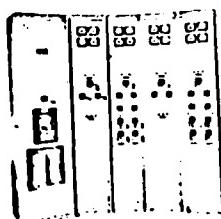
Power Distribution Panel



Control Panels



Control Station



GROUP: 3B-2 HEAVY-FRAMED RACKS, PANEL, ENCLOSED

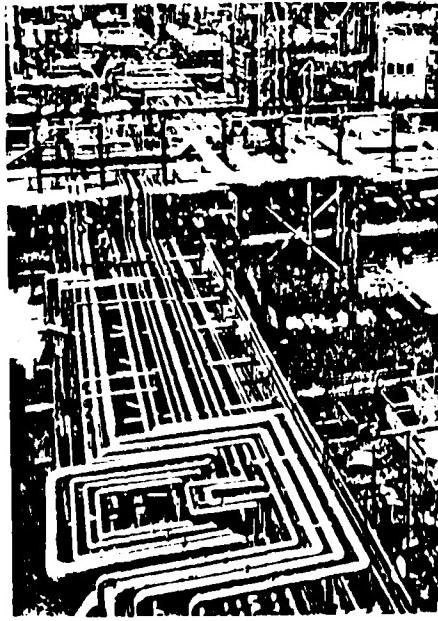
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION ( H/B ≤ 2 )	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES	MISSILES	MANHOURS	DAYS	
SECURED	NOT SECURED				
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>					
3. <u>Moderate to heavy damage:</u>					
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING					
VERTICAL CONFIGURATION ( H/B > 2 )					
1. <u>Little or no damage:</u> Glass broken; some covers bent					
2. <u>Light to moderate damage:</u> Covers bent & blown into components; some plastic electrical components broken; Instrumentation suffers broken external components & loss of calibration	2	1	1	24	3
3. <u>Moderate to heavy damage:</u> External panels heavily damaged and driven against internal components; broken external controls; extensive internal damage	4	2	2	48	5
4. <u>Destroyed:</u> Replacement required					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3	2	1 hr/linear foot		

**UTILITY DISTRIBUTION EQUIPMENT**

**TYPE:** Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

**EQUIPMENT PAGE NO.** 3B-3

**EXAMPLES**  
**Piping Arrays**



**Piping Array**

GROUP: 3B-3 UTILITY DISTRIBUTION EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	SECURED	NOT SECURED	MANHOURS	DAYS	
<b>DAMAGE DESCRIPTION</b>					
<b>HORIZONTAL CONFIGURATION ( H/B ≤ 2 )</b>					
1. <u>Little or no damage:</u> Some deformation of piping and bus covers					
2. <u>Light to moderate damage:</u> Breakage of some electrical components; many fasteners broken with much pipe deformation; air lines suffer cracks; some electrical conductors damaged.	3	2	3	3 hr/100 ft	
3. <u>Moderate to heavy damage:</u> Many pipes torn from mounts & terminations; buses heavily damaged; insulators & standoffs broken.	6	3	4	10 hr/100 ft	
4. <u>Destroyed:</u>					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>					
<b>VERTICAL CONFIGURATION ( H/B &gt; 2 )</b>					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	2	2	2	4 hr/100 ft	
3. <u>Moderate to heavy damage:</u>	4	3	3	15 hr/100 ft	
4. <u>Destroyed:</u>					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>					
PAGE 3B-3	UTILITY DISTRIBUTION EQUIPMENT				

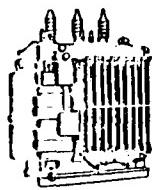
SUBSTATION-TYPE EQUIPMENT

EQUIPMENT PAGE NO.

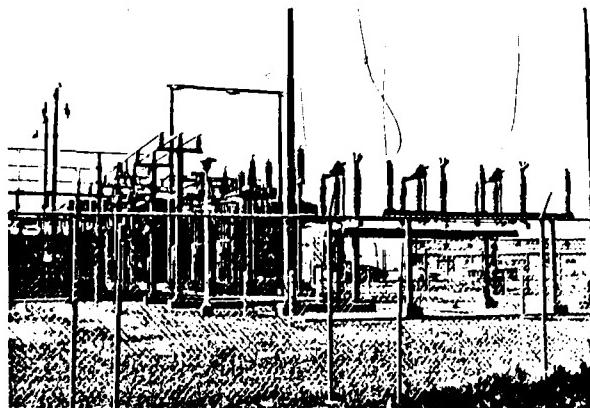
3B-4

TYPE:

Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds



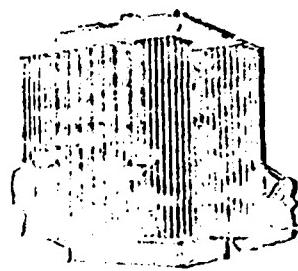
10 MVA Power Transformer



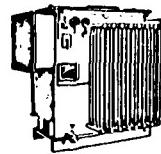
Transformers and Switchgear

EXAMPLES

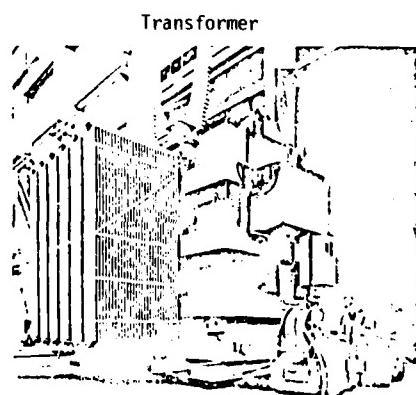
MVA Class Breakers  
Main Transformers



MVA Class  
Transformer



Load Center  
Transformer



Transformer

GROUP:	3B-4 SUBSTATION-TYPE EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
	DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION ( H/B ≤ 2 )					
1.	<u>Little or no damage:</u> Some insulator damage from missiles; cooling radiators deformed					
2.	<u>Light to moderate damage:</u> Radiators damaged & leaking; wiring torn loose; missile punctures in some casings.	5	3	3	14	3
3.	<u>Moderate to heavy damage:</u> Power connections broken; heavy insulator breakage; sides of transformers & circuit breakers distorted & ruptured; some overturning of components.	8	6	5	48	8
4.	<u>Destroyed:</u>					
	SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	7	5		3	1
	VERTICAL CONFIGURATION ( H/B > 2 )					
1.	<u>Little or no damage:</u>					
2.	<u>Light to moderate damage:</u>	4	2	2	16	3
3.	<u>Moderate to heavy damage:</u>	7	5	3	48	8
4.	<u>Destroyed:</u>					
	SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	6	4		4	1

TYPE: MATERIAL STORAGE UNITS

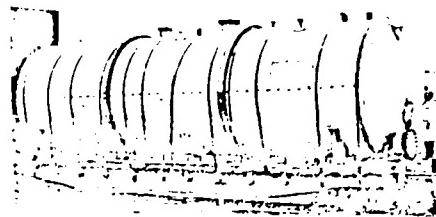
EQUIPMENT PAGE NO. 3C-1

Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

EXAMPLES

Large Bins

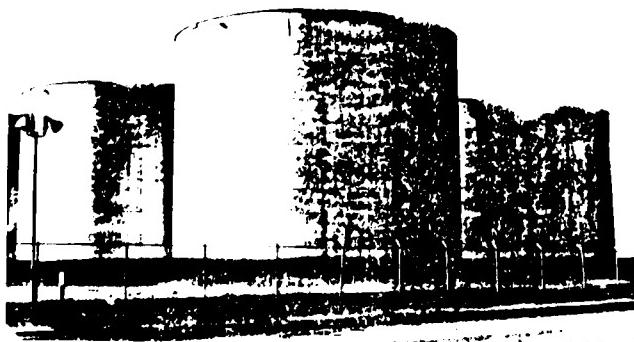
Tanks



Dewatering Tank



Storage Tanks



Storage Tanks

GROUP: 3C-1 MATERIAL STORAGE UNITS	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	FULL	EMPTY	MANHOURS	DAYS	
<b>DAMAGE DESCRIPTION</b>					
<b>HORIZONTAL CONFIGURATION ( H/B ≤ 2 )</b>					
1. <u>Little or no damage:</u> Some distortion of side walls					
2. <u>Light to moderate damage:</u> Some leakage; plates bent or buckled; sides knocked in.	3	1	1	8	1
3. <u>Moderate to heavy damage:</u> Piping broken loose; substantial leakage; some separation from foundation/frame.	5	1.5	1.5	24	2
4. <u>Destroyed:</u>					
<b>REVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>		4	1.5	3	1
<b>VERTICAL CONFIGURATION ( H/B &gt; 2 )</b>					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	2	1	1	12	1
3. <u>Moderate to heavy damage:</u>	4	1.5	1.5	36	2
4. <u>Destroyed:</u>					
<b>REVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>		3	1	4	1
PAGE 3C-1	MATERIAL STORAGE UNITS				

**LIGHT-WALLED ELEVATED CONSTRUCTIONS**

TYPE:

Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

EQUIPMENT PAGE NO.

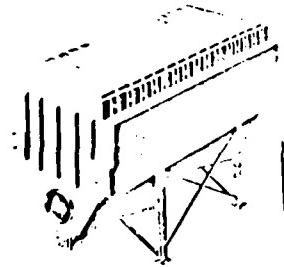
3C-2

**EXAMPLES**

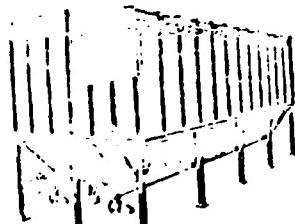
Baghouses  
Large Hoppers  
Cooling Towers  
Chillers



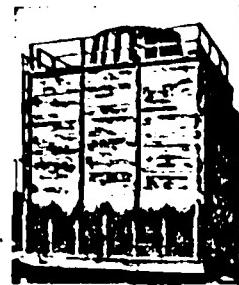
Evaporator Condenser



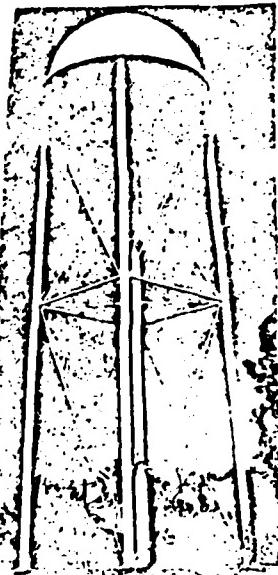
Dust Recovery Pulsejet Filter Collection Units



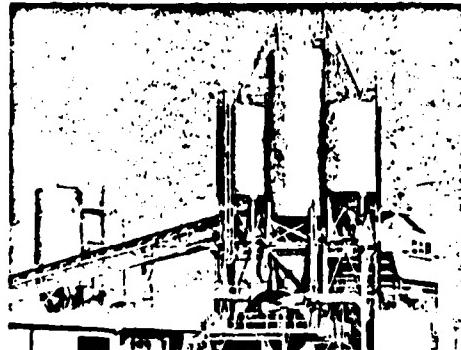
Chiller



Cooling Tower



Elevated Steel Tanks



GROUP: 3C-2 LIGHT-WALLED ELEVATED CONSTRUCTIONS		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
HORIZONTAL CONFIGURATION ( H/B ≤ 2 )		FULL	EMPTY			
1. <u>Little or no damage:</u>	Some side wall damage					
2. <u>Light to moderate damage:</u>	Sides bent/buckled; supporting structure slightly damaged; breakable parts fractured; light fan housings deformed.	2	1	1	8	1
3. <u>Moderate to heavy damage:</u>	Frame distorted/buckled; fans destroyed; electrical components broken; pipe connections damaged; light internal components damaged by buckled walls supporting structure deformed.	4	2	2	32	2
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		3	2		3	1
VERTICAL CONFIGURATION ( H/B > 2 )						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>						
3. <u>Moderate to heavy damage:</u>						
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING						

**HEAVY-WALLED VESSELS, MOBILE (POTENTIAL RESOURCE)**

EQUIPMENT PAGE NO.

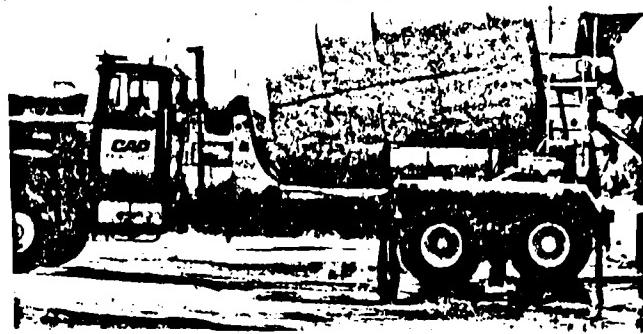
3D-1

TYPE:

Minimum Dimensions: (15x15x20) Feet - Minimum Weight: 30,000 Pounds

EXAMPLES

Mobile Heavy Wall Vessels  
Pressure Vessels



Mobile Heavy Wall Vessels



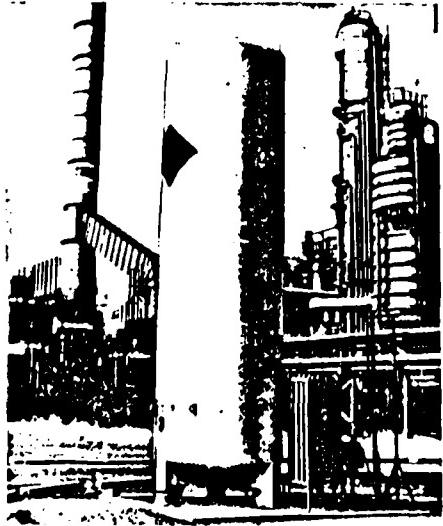
GROUP:	3D-1 HEAVY-WALLED VESSELS, MOBILE (POTENTIAL RESOURCE)	BLAST LEVEL (PSI)			RECOVERY			
		BLAST w/o MISSILES		MISSILES	MANHOURS			
		SECURED	NOT SECURED			DAYS		
DAMAGE DESCRIPTION								
HORIZONTAL CONFIGURATION ( H/B ≤ 2 )								
1.	<u>Little or no damage:</u> Light accessories damaged							
2.	<u>Light to moderate damage:</u> Controls damaged; breakable components fractured; rubber tires damaged by missiles.	4		3	8	1		
3.	<u>Moderate to heavy damage:</u> Controls & accessories heavily damaged; tank displaced from mounts; piping broken from connections.	6	n/a	4	12	1		
4.	<u>Destroyed:</u>							
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING								
VERTICAL CONFIGURATION ( H/B > 2 )								
1.	<u>Little or no damage:</u>							
2.	<u>Light to moderate damage:</u>							
3.	<u>Moderate to heavy damage:</u>							
4.	<u>Destroyed:</u>							
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING								
PAGE	3D-1	HEAVY-WALLED VESSELS, MOBILE (POTENTIAL RESOURCE)						

TYPE: HEAVY-WALLED LIQUID/GAS STORAGE VESSELS      EQUIPMENT PAGE NO. 3D-2

Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

EXAMPLES

Special Tank  
LPG Storage



LPG Storage



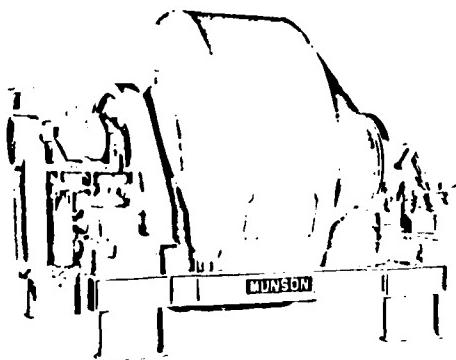
Special Tank

GROUP: 30-2 HEAVY-WALLED LIQUID/GAS STORAGE VESSELS		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	FULL	EMPTY				
HORIZONTAL CONFIGURATION ( H/B ≤ 2 )						
1. <u>Little or no damage:</u> Some instrumentation damage						
2. <u>Light to moderate damage:</u> Light components damaged (panels, covers, etc.); some pipes & connections damaged; missile damage to external components.	4	3	2	8	1	
3. <u>Moderate to heavy damage:</u> Piping damaged; some side wall damage; frame & supports distorted; some anchors broken; heavy missile damage to external components.	6	5	4	16	2	
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	5	4		6	1	
VERTICAL CONFIGURATION ( H/B > 2 )						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>	3	2	2	12	1	
3. <u>Moderate to heavy damage:</u>	6	5	4	20	2	
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	5	4		6	1	

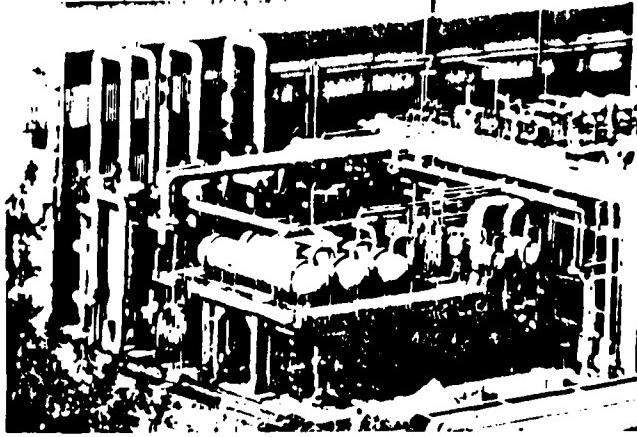
TYPE: HEAVY-WALLED PROCESSING VESSELS EQUIPMENT PAGE NO. 3D-3  
Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

EXAMPLES

Autoclaves  
Reactors  
"Cat" Crackers  
High Pressure Processing Equipment



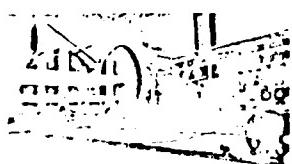
Rotary Batch Mixer



High Pressure Processing Equipment



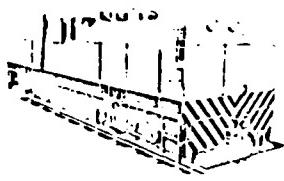
Autoclaves



Heat Exchanger

GROUP: 3D-3 HEAVY-WALLED PROCESSING VESSELS		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		FULL	EMPTY			
1. <u>Little or no damage:</u>	Light instrumentation damage.					
2. <u>Light to moderate damage:</u>	Light components heavily damaged; piping damaged and leaking at connections.	3	2	2	8	1
3. <u>Moderate to heavy damage:</u>	Heavy piping damage; frame/supports distorted; unit displaced off foundation.	6	4	4	20	2
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		5	3		4	1
VERTICAL CONFIGURATION ( H/B > 2 )						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>		3	2	2	12	1
3. <u>Moderate to heavy damage:</u>		4	4	4	24	2
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		4	3		5	1

TYPE: MOBILE MATERIAL HANDLING EQUIPMENT (POTENTIAL RESOURCES) EQUIPMENT PAGE NO. 3E-1  
Minimum Dimensions: (15x15x20) Feet - Minimum Weight: 30,000 Pounds.



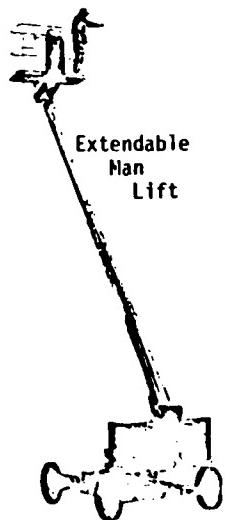
Locomotive

EXAMPLES

Locomotives  
Large Trucks  
Carriers



Self-Propelled Telescopic  
Car Loader



Extendable  
Man  
Lift

GROUP: 3E-1 MOBILE MATERIAL HANDLING EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES		
	SECURED	NOT SECURED	MANHOURS	DAYS	
<b>DAMAGE DESCRIPTION</b> <b>HORIZONTAL CONFIGURATION ( H/B ≤ 2 )</b>					
1. <u>Little or no damage:</u> Covers & guards bent; glass broken; loosely fitting particles blown away.					
2. <u>Light to moderate damage:</u> Electrical equipment damaged; wiring torn loose; covers, guards & panels heavily damaged; instrumentation destroyed; controls damaged; lightly constructed items bent & broken.	4	2	2	24	2
3. <u>Moderate to heavy damage:</u> Damage to heavy welded parts; some broken castings; severe motor damage; controls broken; cabling and piping torn off.	6	5	3	48	4
4. <u>Destroyed:</u>					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>	5	4		4	1
<b>VERTICAL CONFIGURATION ( H/B &gt; 2 )</b>					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	3	2	2	32	2
3. <u>Moderate to heavy damage:</u>	6	4	3	52	6
4. <u>Destroyed:</u>					
<b>SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING</b>	5	3		4	1
PAGE 3E-1	MOBILE MATERIAL HANDLING EQUIPMENT				

**MOVABLE/TRACKED MATERIAL HANDLING EQUIPMENT**

EQUIPMENT PAGE NO.

3F-2

**TYPE:**

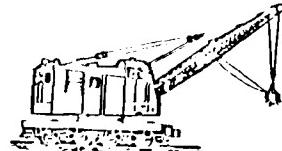
Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

**EXAMPLES**

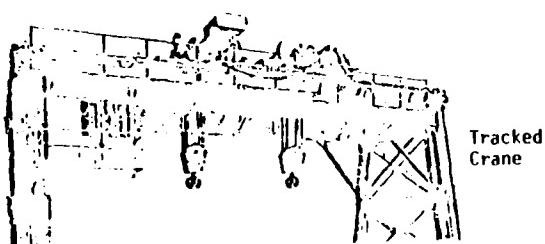
Large Bridge Cranes  
Monorail Cranes  
Rail Car Dumpers



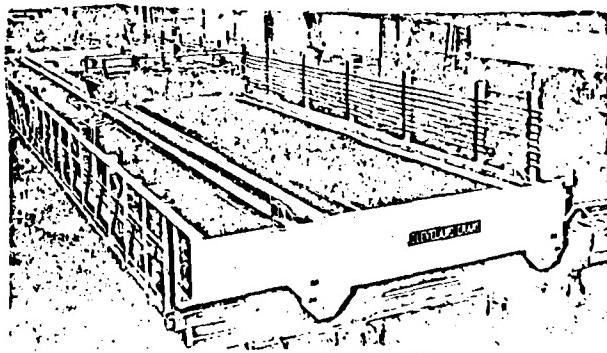
Bridge Crane



Tracked Crane



Tracked Crane



Overhead Crane

GROUP: 3E-2 MOBILE/TRACKED MATERIAL HANDLING EQUIPMENT		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION		BLAST w/o MISSILES		MISSILES	RECOVERY	
HORIZONTAL CONFIGURATION ( H/B ≤ 2 )		SECURED	NOT SECURED		MANHOURS	DAYS
1. <u>Little or no damage:</u> Wiring & buses damaged; covers bent/blown off; glass broken.						
2. <u>Light to moderate damage:</u> Wiring and buses heavily damaged; motors damaged; instrumentation broken; piping damaged; controls & accessories broken.		4	3	2	32	3
3. <u>Moderate to heavy damage:</u> Structural damage; wheels & tracks misaligned; motors misaligned & heavily damaged; controls destroyed; instrumentation and accessories destroyed.		8	5	3	48	4
4. <u>Destroyed:</u> Replacement required.						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		6	4		4	2
VERTICAL CONFIGURATION ( H/B > 2 ) OR ELEVATED						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>		3	2	2	36	3
3. <u>Moderate to heavy damage:</u>		6	4	3	56	4
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		5	3	3	4	2

TYPE: STATIONARY MATERIAL HANDLING EQUIPMENT

EQUIPMENT PAGE NO.

3E-3

Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

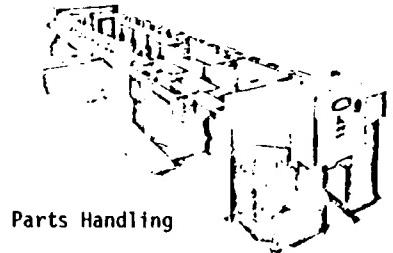
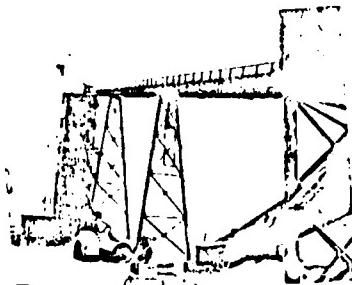
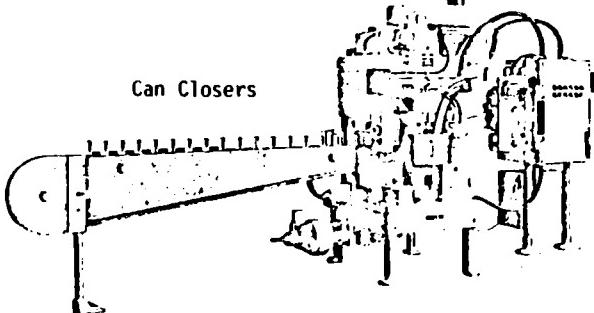
EXAMPLES

Can Feeders

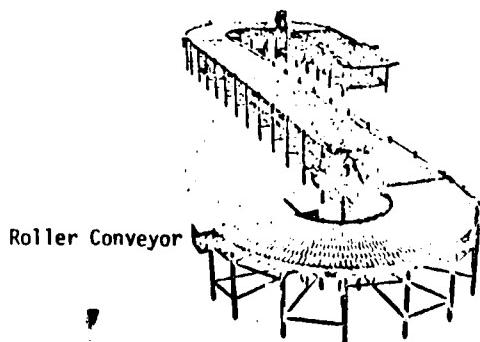
Conveyors

Material Elevators

Grease Slides



Parts Handling



Roller Conveyor

GROUP: 3E-3 STATIONARY MATERIAL HANDLING EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
DAMAGE DESCRIPTION	SECURED	NOT SECURED			
HORIZONTAL CONFIGURATION ( H/B ≤ 2 )					
1. <u>Little or no damage:</u> Some panels & covers bent					
2. <u>Light to moderate damage:</u> Missiles and buckling covers break some components; some mechanical misalignment; light frames distort.	3	2	2	8	1
3. <u>Moderate to heavy damage:</u> Feed screws, rollers, moving parts jammed/misaligned; light components heavily damaged; motors & wiring damaged; anchor bolts & fasteners broken.	6	3	3	12	1
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	4	3	3	3	1
VERTICAL CONFIGURATION ( H/B > 2 )					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	3	2	2	12	1
3. <u>Moderate to heavy damage:</u>	4	3	4	16	2
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	4	3		4	1

**TYPE:** SIMPLE REFRACTORY CONSTRUCTIONS

EQUIPMENT PAGE NO.

3F-1

Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

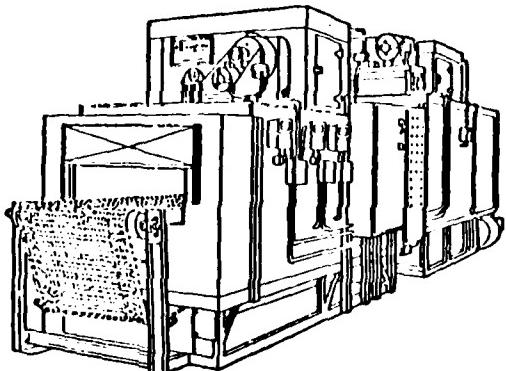
EXAMPLES

Box-Type Furnaces

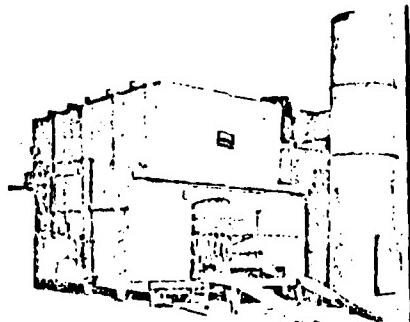
Ovens

Masonry Buildings and vaults

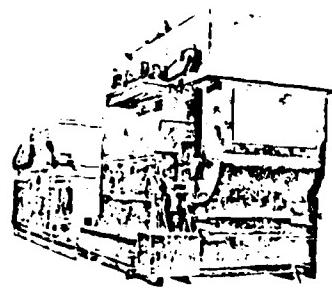
Continuous Oven



Oven



Box Furnace



Process Oven

GROUP: 3F-1 SIMPLE REFRACTORY CONSTRUCTIONS	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES	NOT SECURED	MISSILES		
				MANHOURS	DAYS
HORIZONTAL CONFIGURATION ( H/B ≤ 2 )					
1. <u>Little or no damage:</u> Some distortion & damage of light components.	2		1	8	1
2. <u>Light to moderate damage:</u> Doors distorted & knocked from tracks/hinges; some masonry cracks & loose bricks; some block damage.	3	n/a	3	16	2
3. <u>Moderate to heavy damage:</u> Parts of masonry/brickwork blown down; accessories damaged; some walls fail; many blocks/bricks fractured; doors wrenched loose.					
4. <u>Destroyed:</u> Bricks/blocks broken & turned into missiles.					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3			4	1
VERTICAL CONFIGURATION ( H/B > 2 )					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>					
3. <u>Moderate to heavy damage:</u>					
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING					
PAGE 3F-1	SIMPLE REFRACTORY CONSTRUCTIONS				

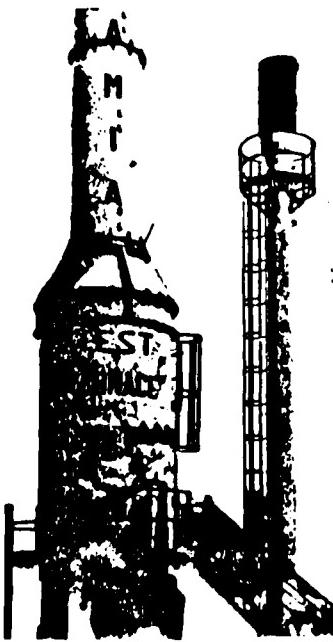
**REFRACTORY-LINED EQUIPMENT**

**TYPE:**

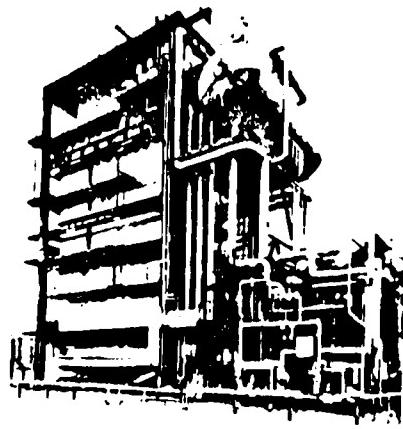
**Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds**

**EQUIPMENT PAGE NO.**

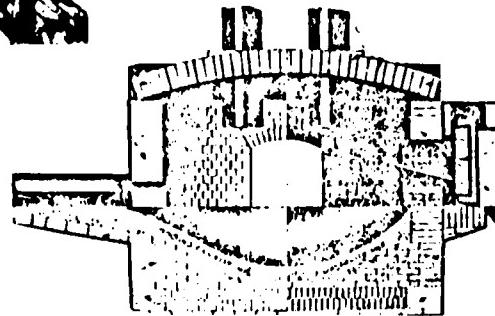
**3F-2**



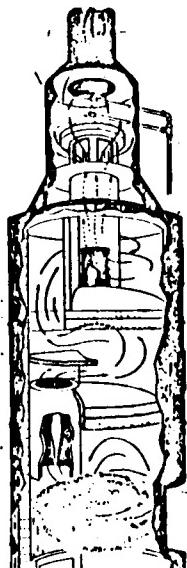
**R & D Furnace**



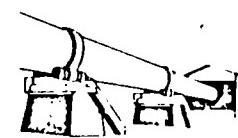
**Boiler**



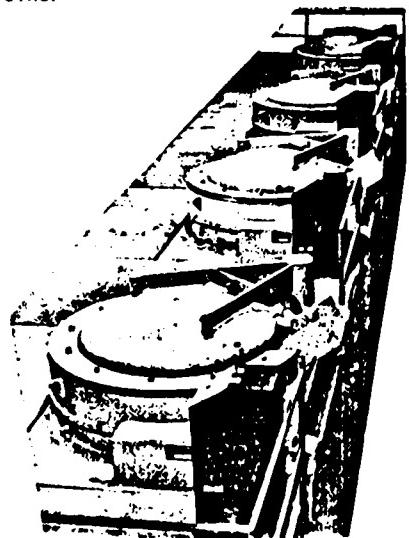
**Electric Arc Furnace**



**Incinerator**



**Calciner**



**Induction Furnace**

**EXAMPLES**

**Boilers**

**Arc and Induction Furnaces**

**Calciners**



**STACKS**

**TYPE:**

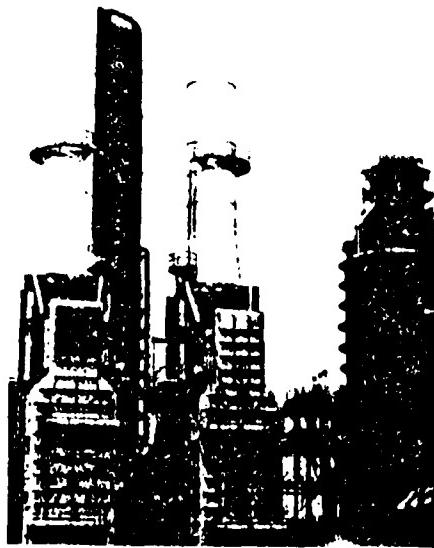
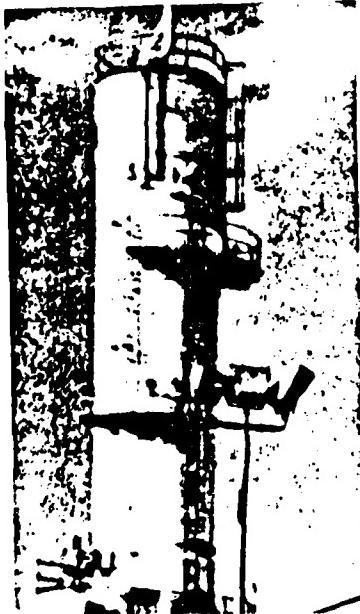
**EQUIPMENT PAGE NO.**

**3F-3**

**Minimum Dimensions: (15x15x20) Feet - Minimum Weight: 30,000 Pounds**

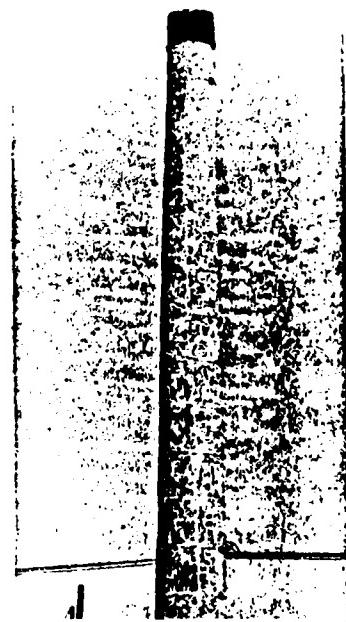
**EXAMPLES**

Exhaust Stacks  
Concrete Silos  
Distillation Towers  
Cat Crackers  
Metal Stacks  
Petroleum Processing Towers  
Reduction Column



**Exhaust Stacks**

**Reduction Column**



**Masonry Stack**

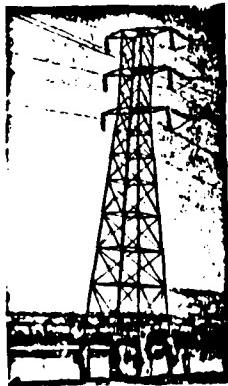
GROUP: 3F-3 STACKS		BLAST LEVEL (PSI)		RECOVERY	
DAMAGE DESCRIPTION	BLAST w/o MISSILES	MISSILES	MANHOURS	DAYS	
1. <u>Little or no damage:</u> Crack appear - most damage due to wind loads & drag effects which increase with blast psi.	0.5		0.5	8	1
2. <u>Light to moderate damage:</u> Some breakage of masonry; many large & significant cracks rend structure.	1.5	n/a	1	12	1
3. <u>Moderate to heavy damage:</u> Possible truncation of stack; substantial masonry damage/brick breakage; structure may be unstable					
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	1.5		4	1	
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING					
PAGE 3F-3			STACKS		

**METAL TOWERS AND ASSEMBLIES**

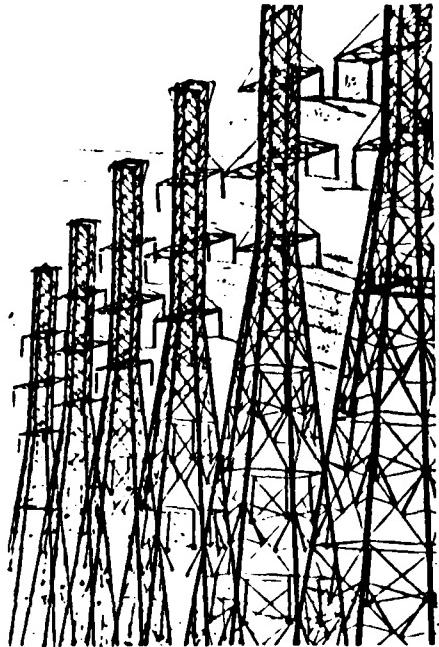
**TYPE:** Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

**EQUIPMENT PAGE NO.**

**3G-1**



**Transmission Towers**



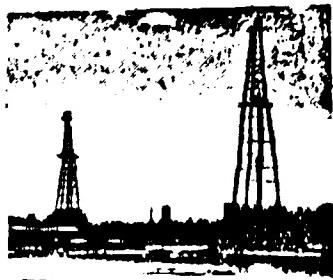
**EXAMPLES**

**Transmission Towers**

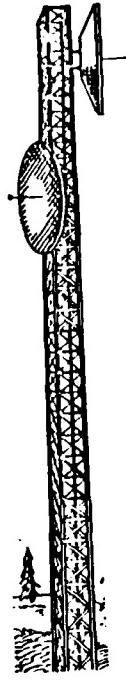
**Scaffolding**

**Catwalks**

**Oil Derricks**



**Oil Derricks**



**Tower**

GROUP: 3G-1 METAL TOWERS & ASSEMBLIES	DAMAGE DESCRIPTION	BLAST LEVEL (PSI)			RECOVERY	
		BLAST w/o MISSILES		MISSILES		
		SECURED	NOT SECURED	MANHOURS	DAYS	
1. <u>Little or no damage:</u> Some distortion of covers of antennas						
2. <u>Light to moderate damage:</u> Covers blown off dish antennas; antennas disoriented; Long wire antennas may fail; some distortion.		1	0.5	1	8	1
3. <u>Moderate to heavy damage:</u> Long wire antennas down; dish antennas damaged; columns deformed		2	1	1	16	2
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		2	1		4	1
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING						
PAGE 3G-1		METAL TOWERS & ASSEMBLIES				

CRISIS RELOCATION INDUSTRIAL HARDENING PLAN

Booklet 8B

**EQUIPMENT INDEX**

This is one of ten booklets of the Industrial Hardening Manual  
developed for the  
Federal Emergency Management Agency  
under Contract No. EMW-C-0154, Work Unit 1124E

**SCIENTIFIC SERVICE, Inc.**  
Redwood City, California 94063

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# **INDUSTRIAL PROTECTION GUIDE**

**CRISIS RELOCATION  
INDUSTRIAL HARDENING PLAN**

**HARDENING  
ACTIVITIES  
BOOKLET 9**

**EMERGENCY RELIEF SERVICE, INC.**

## **CRISIS RELOCATION INDUSTRIAL HARDENING PLAN**

Booklet 9

### **HARDENING ALTERNATIVES**

This is one of ten booklets of the Industrial Hardening Manual  
developed for the  
Federal Emergency Management Agency  
under Contract No. EMW-C-0154, Work Unit 1124E

**SCIENTIFIC SERVICE, Inc.**  
Redwood City, California 94063

Booklet 9

## HARDENING ALTERNATIVES

Hardening Operations Manager: \_\_\_\_\_  
(name)

Alternate: \_\_\_\_\_  
(name)

**Objective:** To identify specific hardening methods appropriate to your plant.

### GENERAL APPROACH AND GUIDELINES

Hardening Alternatives: Basic approaches to hardening solutions.

Hardening choices occur initially with the decision to either harden the equipment, harden replacement equipment, harden materials or alternative process equipment, or evacuate the equipment to a low-risk area. Alternative decisions occur again when equipment is located inside, on, or adjacent to buildings or other structures that can damage the equipment when they fail. The alternatives for these cases are to move the equipment outdoors, harden the equipment in place, harden the building, or remove the building.

Methods of hardening should be determined for as many alternative approaches as possible so that the most expedient and effective method can be found. List each possible approach, estimate the manpower and other resources required and the new survival rating of the equipment. Compare the time, effort, and improved outcome of the various proposed methods and choose the most effective and expedient approach.

Use combinations of several approaches where possible -- for example, removal of the building siding, guy bracing the structural frame, and shielding equipment in place after packing and burying the attached control components.

## **DESCRIPTION OF HARDENING ALTERNATIVES**

### **Evacuate Equipment:**

Remove equipment to a low-risk area. Usually applicable to small and medium size equipment that is easily transported. Weather protection must be considered. (See Figure 1)

### **Relocate and Harden Equipment Onsite:**

Remove equipment to a safer location onsite where hardening is simpler. (See Figures 2, 3, and 4)

### **Harden Equipment in Place:**

Strengthen or protect the equipment in place to increase its blast resistance. (See Figures 5 and 6)

### **Harden Replacement Materials and Equipment:**

Protect materials and equipment that can be used to replace existing equipment.

### **Substitute-Process Hardening:**

Identify a simpler, substitute process that can be used in place of the present one, and harden the materials, tools, etc., needed to put the alternative process in operation.

Example: Canning foods in recycled cans --

- (1) Use a hand-operated lid roll forming tool to install the lids on the cans;
- (2) Use wax to seal the cans for local distribution.

## GENERAL HARDENING ALTERNATIVES FOR EQUIPMENT IN BUILDINGS

Most equipment is inside, adjacent to, or on buildings or other structures where failure of the building or structure would cause heavy damage to the equipment.

### **Move Equipment:**

Move equipment away from the source of the damage; i.e., heavy building elements. In heavy concrete buildings this will require that the equipment be moved outdoors, clear of the building, and provided with weather protection. In buildings with very lightweight roofs (wood, sheet metal) and heavy reinforced concrete walls, the equipment can be moved to a central location (if it is clear of where walls would fall) to provide protection. When clear of collapsing heavy sections, and anchored to prevent overturning or sliding into other items, equipment will equal its highest blast survival rating in the catalog of Booklet 8. (Figure 7)

### **Harden Equipment:**

Strengthen and/or protect equipment from the collapse of the building or structure. This approach is most effective for equipment that is relatively blast resistant (heavy machinery, steel, heavy-walled pressure vessels) and inside lightweight buildings (wood, sheet metal, asbestos, etc., roofs and siding, etc.). (Figure 8, also 5 and 6)

**Remove Building:**

Remove the source of the initial equipment damage -- missiles created during building wall failures and collapse of the building frame. Some types of structures can be collapsed quickly in controlled directions to avoid equipment. Disassembling the building has the advantage of possibly saving the materials needed for reconstruction. Building members laid flat on the ground have a much greater survival rating (provided they are held down). Removal of concrete block or brick walls eliminates a serious source of missile damage. (Figure 9)

**Harden Building:**

Strengthen steel frames of buildings where siding has been removed by guying, bracing, and reinforcing members and joints. This alternative can be used effectively to increase the survival rating of equipment otherwise damaged by failing beams, trusses, and columns (Figure 9). Guy bracing and reinforcing is also an effective method of protecting overhead bridge cranes. For heavy concrete buildings, below-ground basements can be shored to provide equipment protection (Figure 2).

## SPECIFIC RISK-AREA EQUIPMENT HARDENING METHODS

### **Securing Equipment:**

Bolt and/or weld equipment to solid foundations, or secure equipment in large, stable clumps (see Figure 4 for a simple example) to prevent collision-impact damage from sliding or overturning. Equipment should have a strong base and support frames (and good equipment component attachments to that frame). Provide ductile steel bolt-down angles or brackets where possible to reinforce equipment mounts made of cast steel. For equipment with vertical height greater than the smaller dimension at its base, securing should be combined with guying or bracing, if equipment cannot be placed on its side.

### **Above or Below Grade Burial:**

Equipment can be protected with crushable cushioning materials, covered with a dust barrier (plastic sheet, canvas, blankets, etc.) and then buried under several feet of soil. This effective, proven method for protecting equipment has been tested during weapons test experiments. (Figure 10, 11, and 12)

### **Protective Shelter:**

A framed structure built around and over the equipment to protect equipment from building collapse damage. (Figure 6)

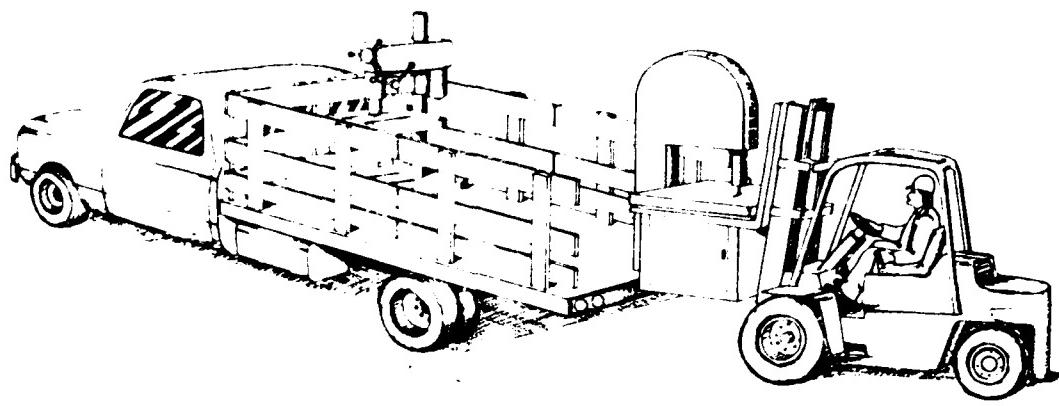
### **Screen Shelter:**

A sandbag or dirt berm, or braced and guyed fence-type structure constructed around the equipment to protect the equipment from missiles and high-velocity winds. (Figure 7)

### **Guying, Bracing, and Anchoring:**

Guying with wire rope or bracing with steel members the upper parts of equipment and structures. Primarily used on immovable, tall equipment with medium to heavy steel frames (Figure 9). Anchors used with guys and bracing, or with stable arrays of equipment packages to prevent sliding (Figure 13).

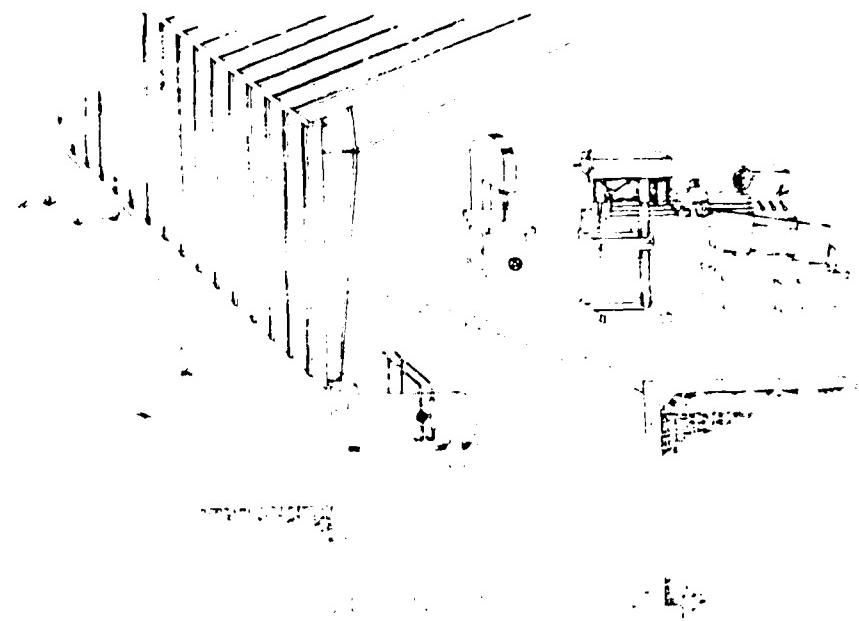
EVACUATE



LOAD EQUIPMENT AND MOVE IT AWAY  
If You Can Take All Of It - Do So!  
If You Can Take Only Part Of It,  
Select the Irreplaceable Items - Key  
Maintenance And Repair Manuals And  
Tools, And Recovery Equipment - To  
Evacuate.

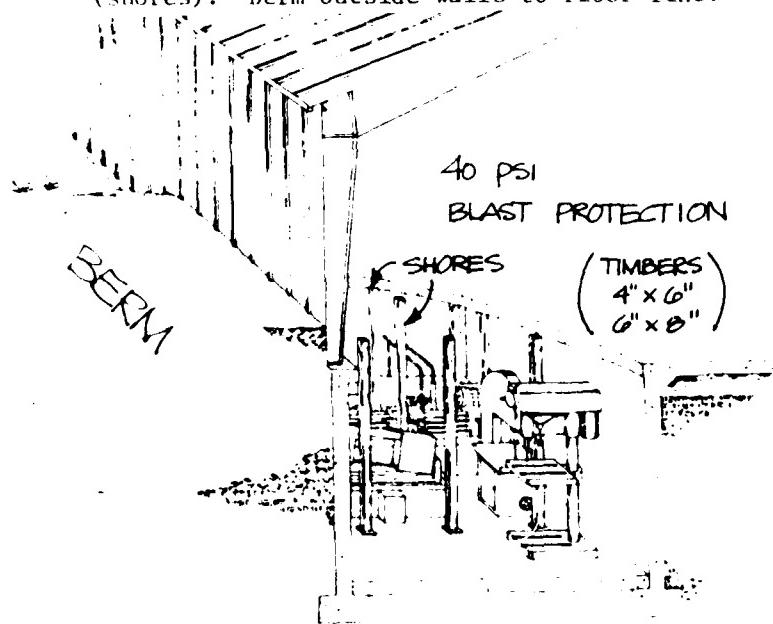
Fig. 1.

MOVE EQUIPMENT TO A SAFER PLACE IN THE PLANT STRUCTURE AND HARDEN  
STRUCTURE...



TO HARDEN STRUCTURE  
(It Must Have a Basement!)

Reinforce basement space with supporting timbers  
(shores). Berm outside walls to floor line.



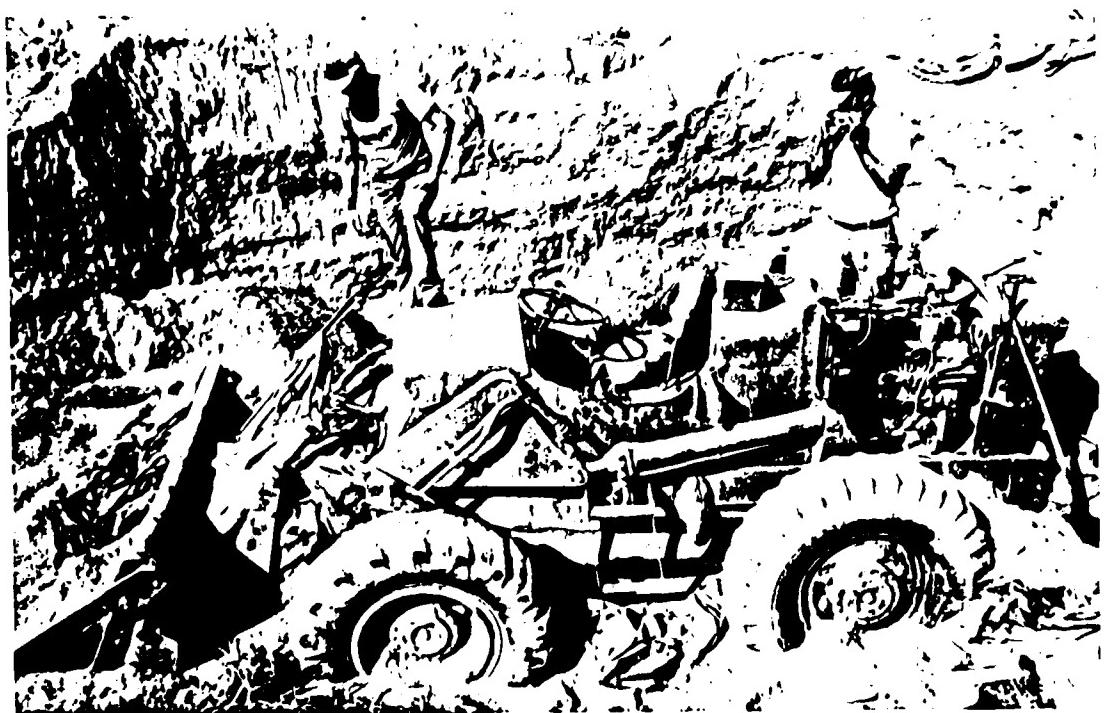
RELOCATE EQUIPMENT UNDERGROUND IN SHORED BASEMENT

Fig. 2.

IF YOU CAN MOVE THE EQUIPMENT BUT CAN'T HAUL IT AWAY ...



BURY IT OUTDOORS  
In Paved Areas - Sandbag It  
Blast Protection: 50 psi



IN OPEN AREAS - PUT IT IN A TRENCH  
(COVER IT IF THERE'S TIME)  
Blast Protection: 20 psi (Open Trench)  
300 psi (Covered Trench With Crushable Layer)

Fig. 3.

Where open space is plentiful and equipment is movable, but you cannot cover it (because cover or covering equipment is lacking) - weld equipment together in clusters that have a ratio of H/B less than  $\frac{1}{2}$ , and place them 2B apart.

Drums (e.g., of hazardous materials) are particularly suitable for this type of hardening (provided they are full and closed). Truckers or climbers webbing (7,000 lb strength) can be used to strap them together.

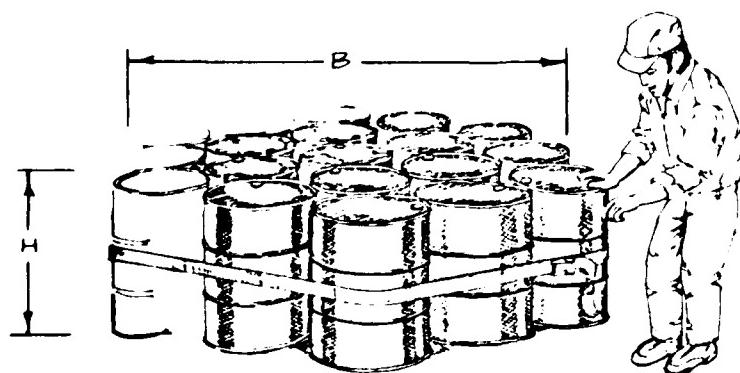
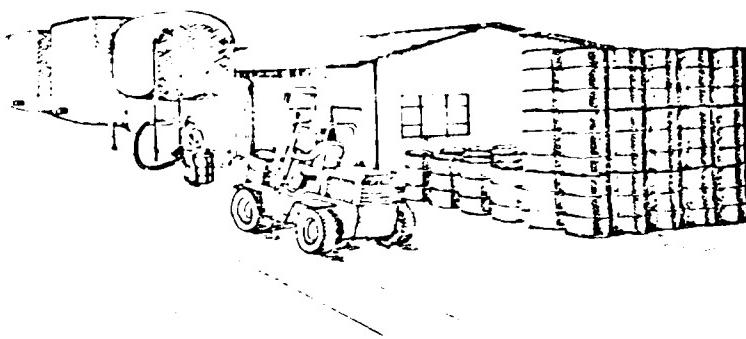
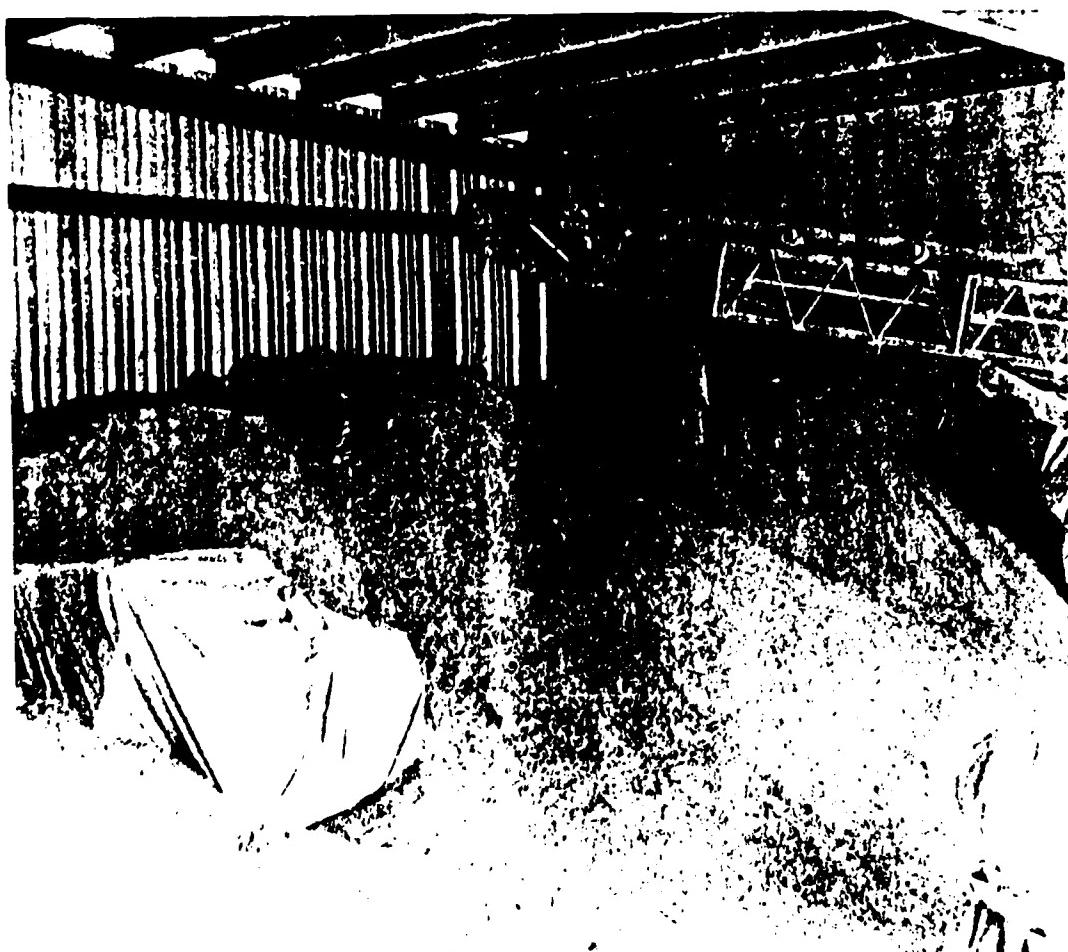


Fig. 4.

BURY IT INDOORS



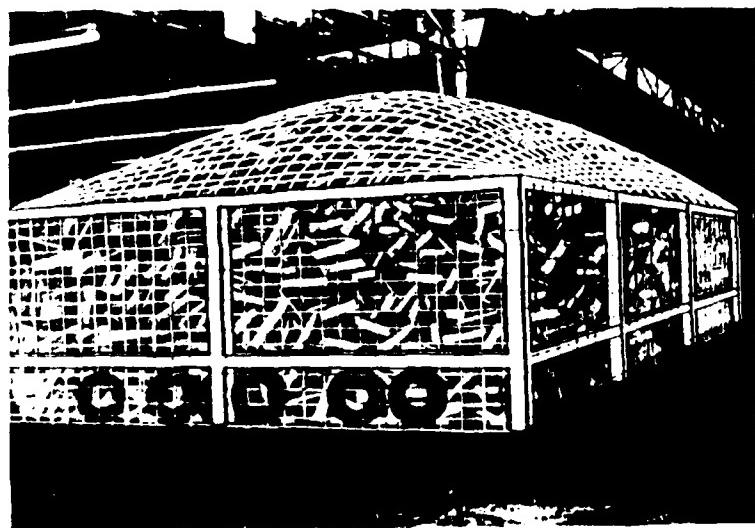
Blast Protection: 300 psi

Fig. 5.

IF YOU CAN'T BURY OR MOVE IT ...



Cluster Movable Equipment Around It; Wedge Wood  
Or Tire Bumpers Between Equipment To Protect  
Knobs, Handles, Etc.

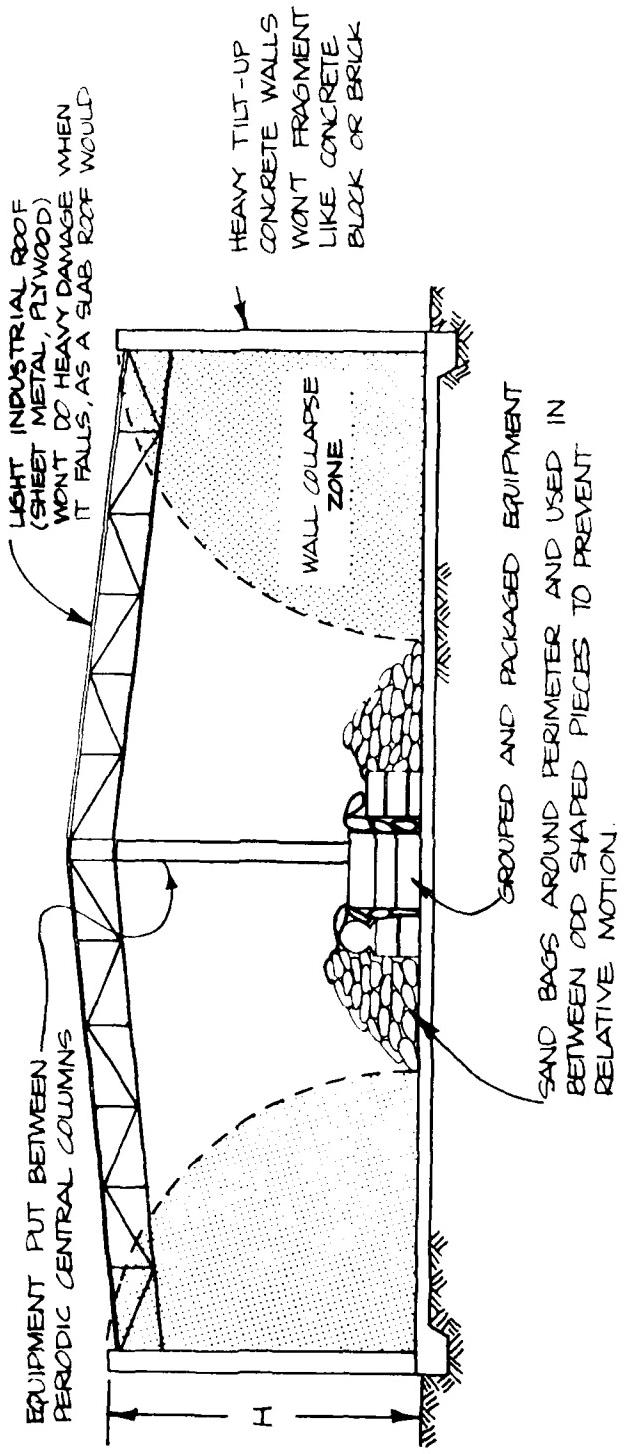


Weld Heavy I-Beam Crib Around it; Add Chain Link  
Fence; Stuff With Tires or Lumber; and Cover.

Blast Protection: 20 to 30 psi

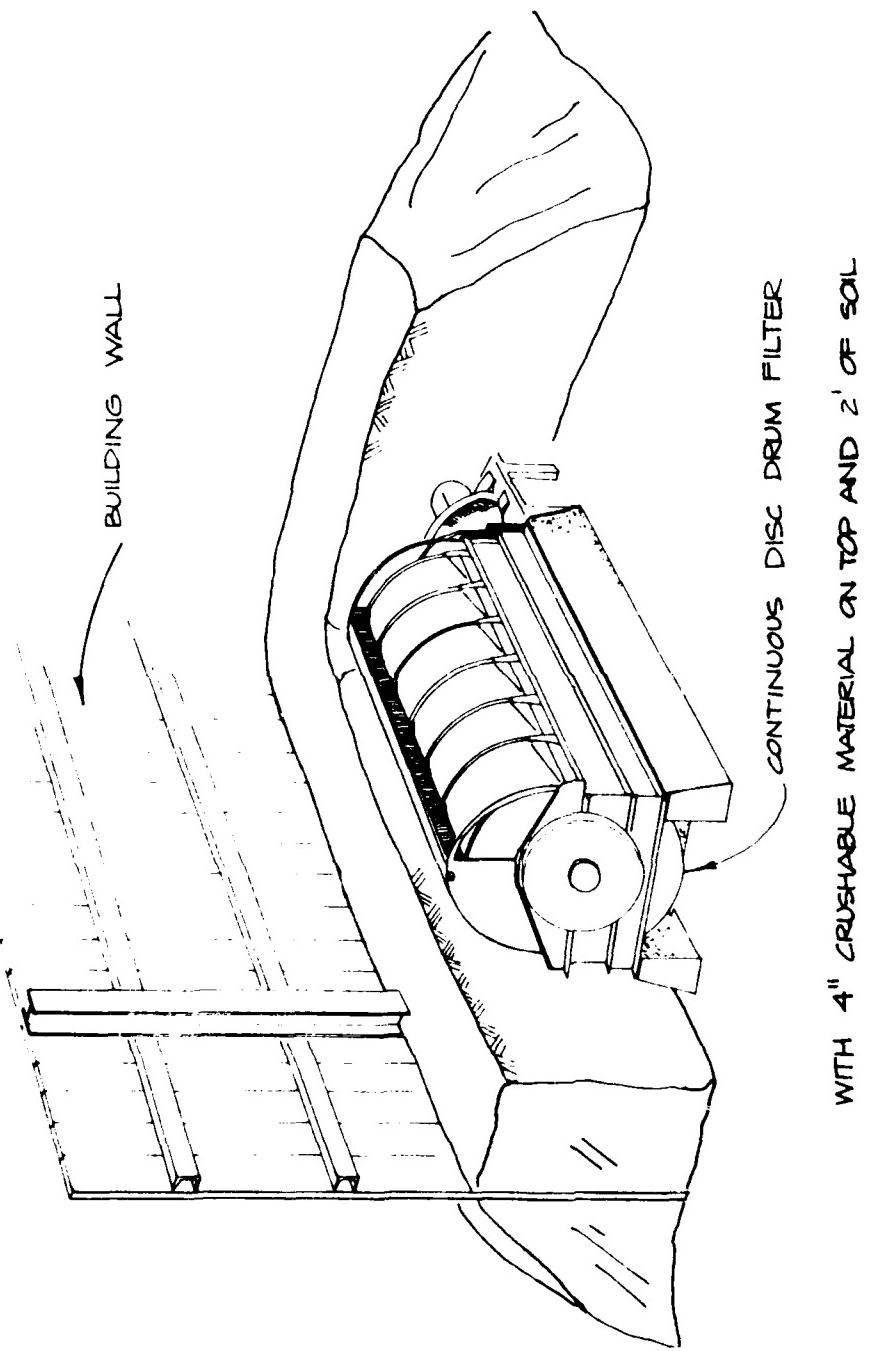
Fig. 6.

- CONDITIONS: Little Outdoor Space, Neighboring Buildings 2 Ft Apart Or Less
- o Fragile equipment evacuated.
  - o Sand bags and grouping of equipment provides protection from missiles, light roof collapse, and high winds. (Light weight equipment cushion packed and crated.)
  - o Equipment moved from heavy-wall collapse zone.



Blast Protection: 5 psi (Light Frame Equipment And Closed Panel Construction)  
25 psi (Heavy Frame Equipment And Open Panel Construction)

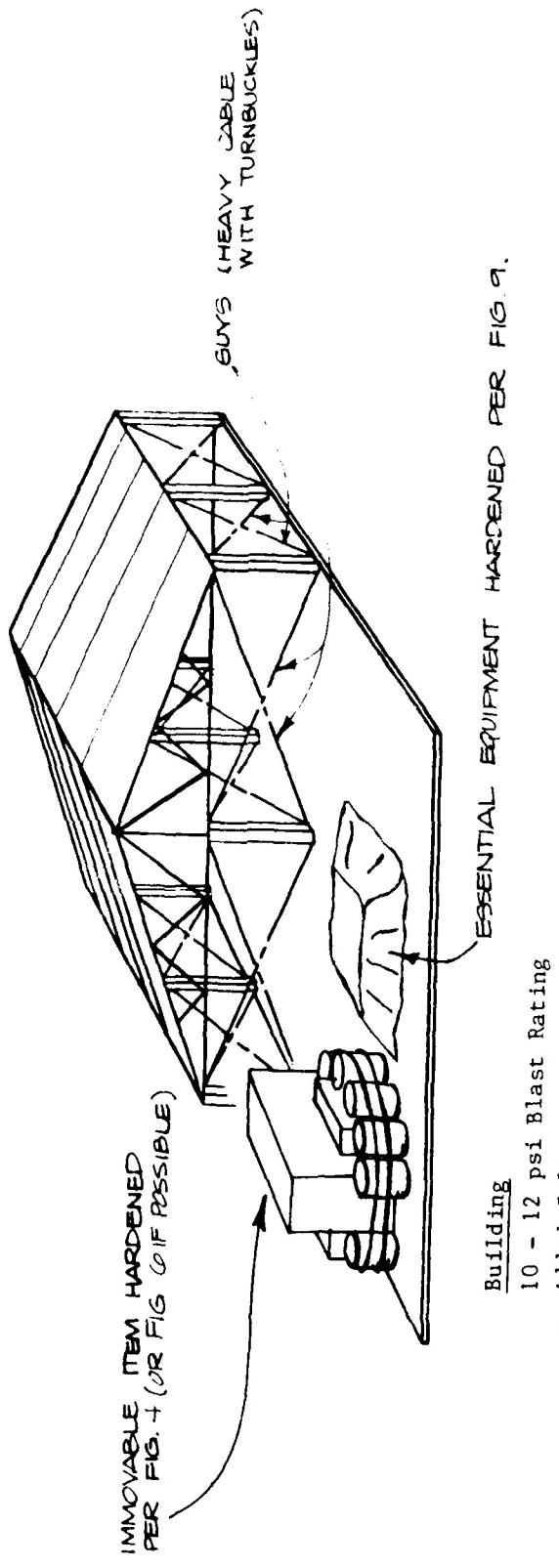
Fig. 7.



IN-PLACE BURIAL INSIDE BUILDING

Blast Protection: 300 psi (Loose Soil Cover)

Fig. 8.



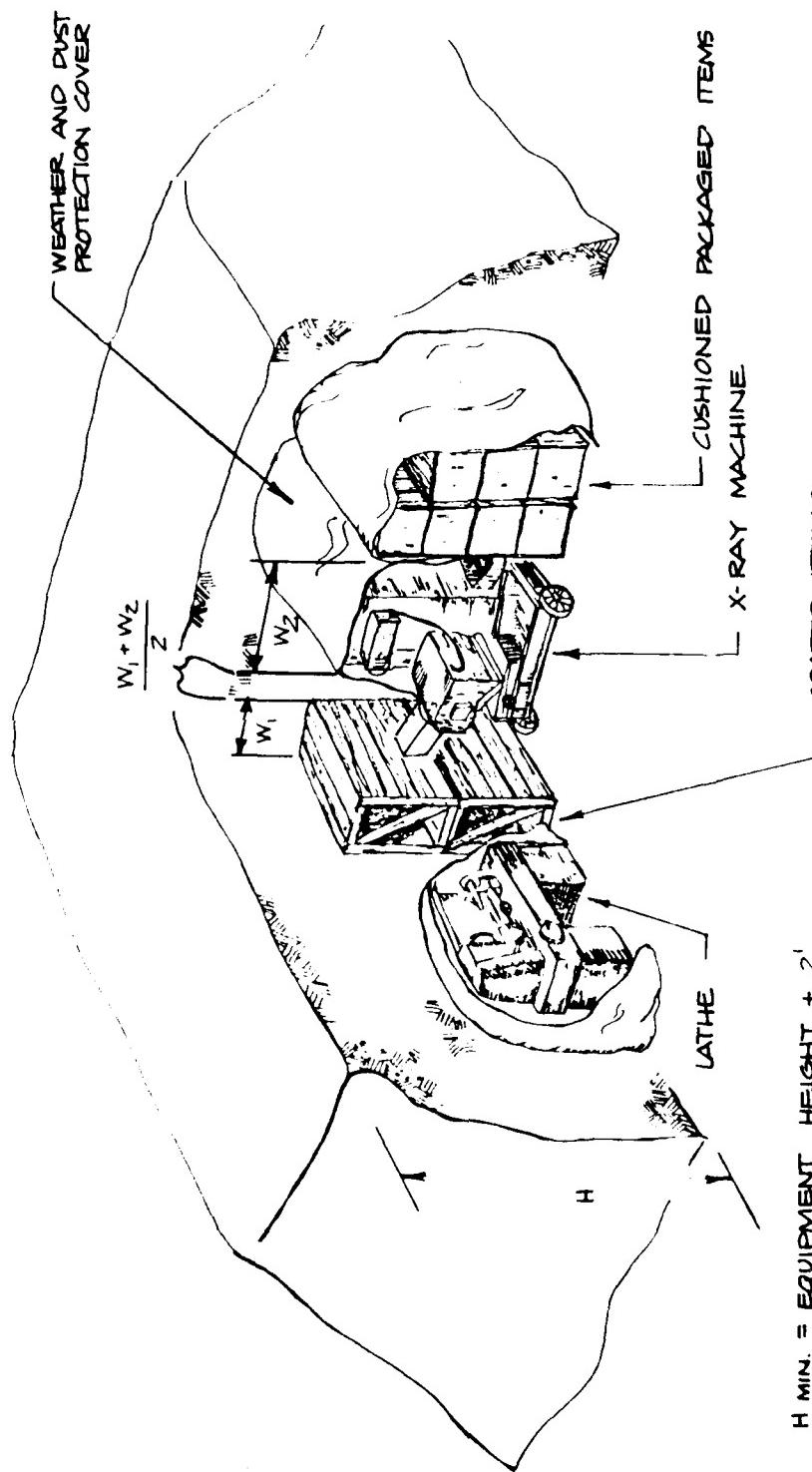
Building

- 10 - 12 Psi Blast Rating
- Added Columns
- Guy Braced Frame

Equipment

- Above Ground Burial of Essential Equipment.
- Cluster of Equipment and Water Filled Barrels Around Immovable Item of Equipment.

Fig. 9.

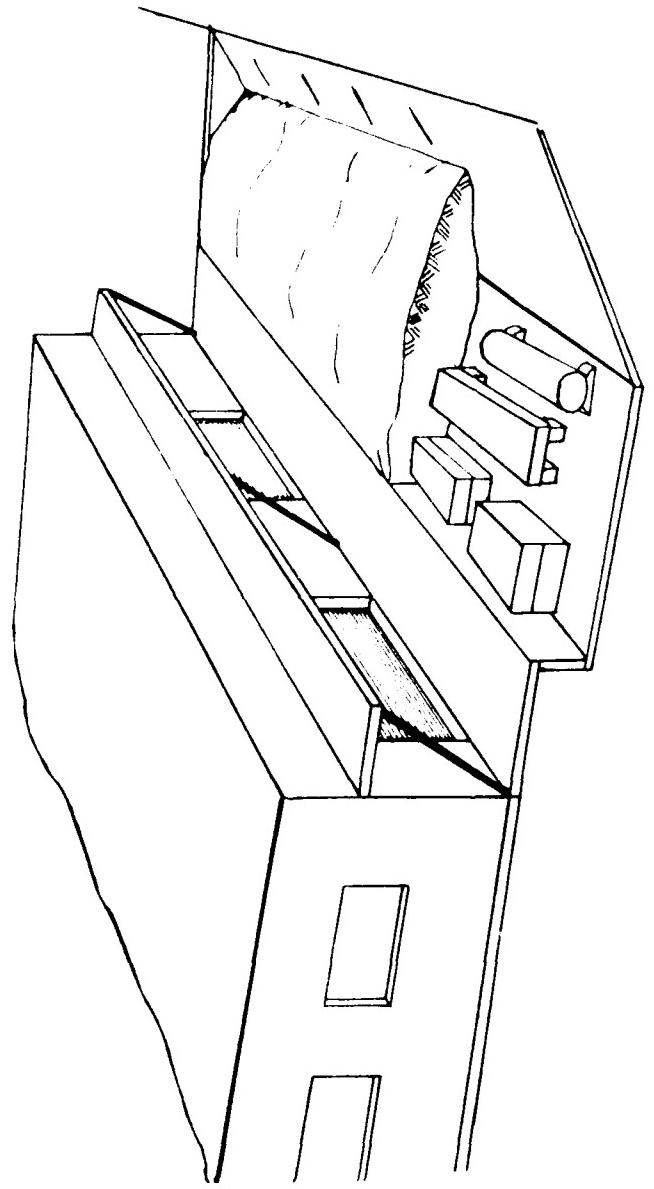


All Equipment Stacks with 4" Crushable Material on Top. Stacks Placed with space between Equal to Half the Combined Width of Adjacent Stacks.

#### ABOVE GROUND BURIAL

Blast Protection: 300 psi (Loose Soil Cover)

Fig. 10.

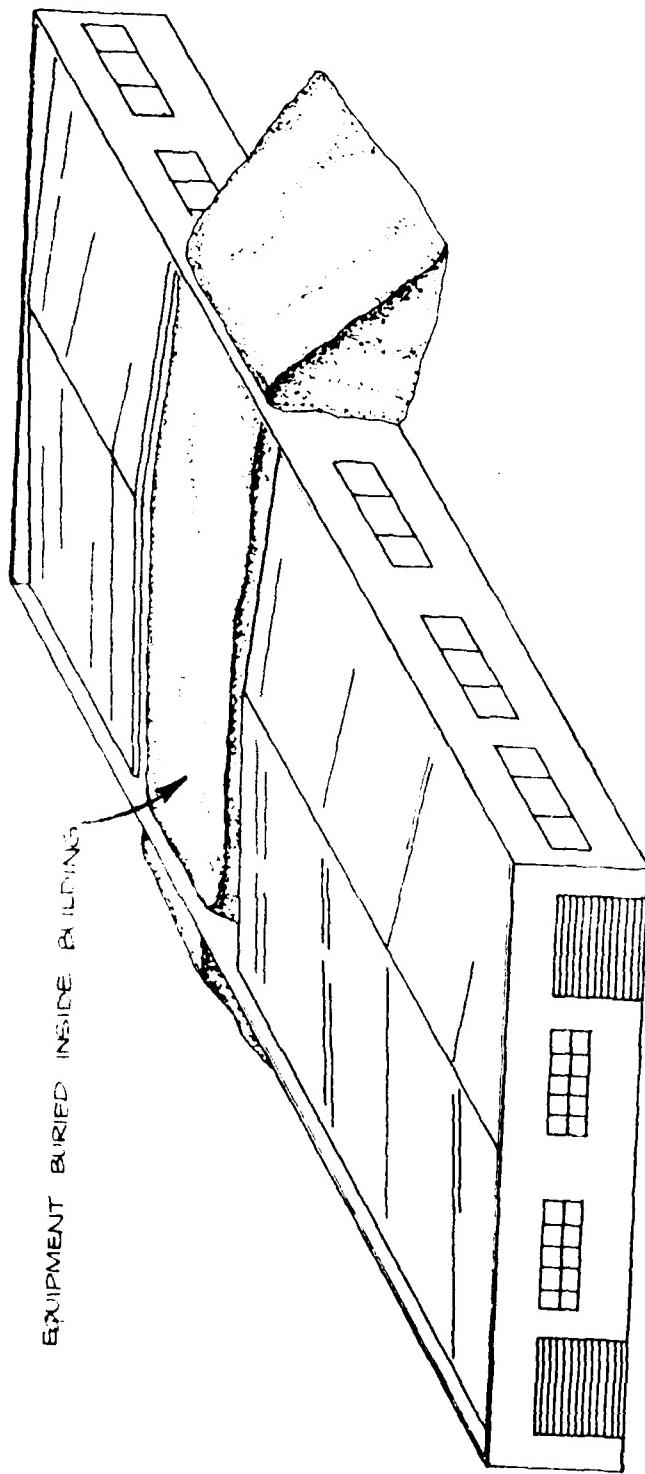


4" Crushable Material on TOP of Each Buried Unit and 2' of Soil Spacing between  
as in Fig. 10.

BURIAL IN LOADING DOCK AREA

Blast Protection: 300 psi (Largest Soil Cover)

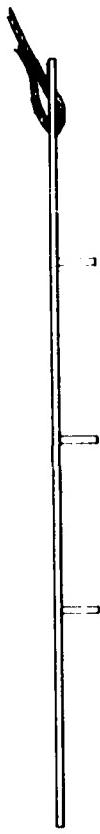
Fig. 11.



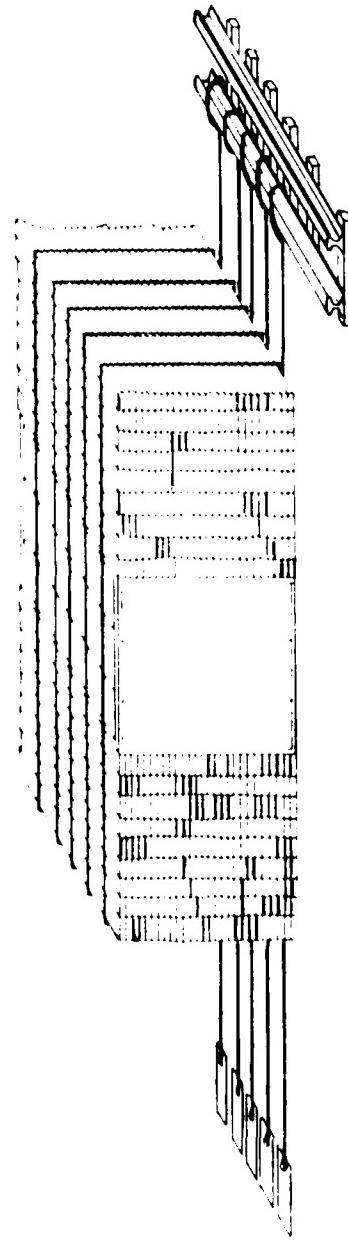
ABOVE GROUND BURIAL

Blast Protection: 50 - 300 psi

Fig. 12.



A. Expedient Anchor.



B. Tiedown Alternative

Fig. 13.

# **INDUSTRIAL PROBLEMS**

**CLOUDS**

**CHARGE REUTZAUER  
INDUSTRIAL HYGIENE PROGRAM**

**REUTZAUER INDUSTRIAL HYGIENE PROGRAM**

**CRISIS RELOCATION INDUSTRIAL HARDENING PLAN**

Booklet 10

**KEY WORKER SHELTER**

This is one of ten booklets of the Industrial Hardening Manual  
developed for the  
Federal Emergency Management Agency  
under Contract No. EMW-C-0154, Work Unit 1124E

**SCIENTIFIC SERVICE, Inc.**  
Redwood City, California 94063

Note: Advance planning for industrial hardening is essential and many activities, including designing and implementing "Key Worker Shelters", can and should be accomplished well in advance of need. However, since there may be circumstances when there will be little advance warning, this booklet has been developed to enable you to accomplish the task in a crisis period; i.e., a few days, provided you plan now.

Booklet 10  
**KEY WORKER SHELTER**

**Coordinator:** \_\_\_\_\_

(name)

**Alternate:** \_\_\_\_\_

(name)

**Objective:** To develop plant site shelter space for key workers of the key industries that operate through the crisis.

This booklet is part of a survival plan in the event of a major disaster. It will be vital to keep some industry operations running during a disaster -- for example, communications and power facilities. It is expected that key worker volunteers will be able to conduct most of these operations during the days and commute to their host areas at night. But some operations will be round-the-clock. In either case, onsite "key worker" emergency shelters will be required at such plants. Such shelters might also be useful at other plants for teams doing late hardening (see Glossary, p. 61) and early recovery, but would take time from hardening activities to build. For those building key worker shelters this booklet outlines the procedures.

- Step 1 -- Determine the number of key workers to be sheltered
- Step 2 -- Examine shelter requirements
- Step 3 -- Survey existing below grade structures for upgrading
- Step 4 -- Survey expedient shelters for upgrading
- Step 5 -- Assess shelter closures and entry alternatives
- Step 6 -- Assess shelter stocking
- Step 7 -- Complete the key worker shelter implementation analysis

## **STEP 1: Determine Number of Key Workers**

- A. Decide exactly what equipment is to continue operating.
- B. Determine the minimum crew required.
- C. Add two additional members, one to monitor the radio and give warning to take shelter, and one to provide backup in case of an injury.

## **STEP 2: Examine Shelter Requirements**

- A. Determine type of shelter needed; i.e., short stay-time, austere shelter (if your plant is on the fringe of a designated risk area and there are no other risk areas between it and the host area, or if there is a major risk area key worker shelter -- with space -- that can be reached in 10 minutes); or long stay-time, fully equipped shelter.
- B. Determine potential shelter availability:
  - (1) Basement or underground space that can be upgraded;
  - (2) Expedient Shelters: Facilities not originally intended for shelter protection or human habitation, which can be adapted with structural upgrading, as necessary, to protect key personnel.
- C. Based on type of shelter, there are general and specific criteria applied to each.

### General Criteria

- o Shelters must be structurally capable of withstanding 40 psi or more and have sufficient radiation protection to limit shelteree exposure to an acceptable level. Only underground shelters are suitable to withstand 40 psi. Adequate radiation protection may be achieved with approximately 3 feet of earth cover (at a density of 110 lb per cubic foot), which will provide a protection factor  $P_f = 1000$ .

- o Shelters should be located so that debris or collapsing buildings, whether adjacent to the shelter or in the neighborhood, would not prevent escape of sheltered personnel.
- o Below ground shelters, unless they are water-tight, should not be located in high ground-water areas, nor in areas subject to flooding from surface runoff, ruptured tanks, or broken pipelines.
- o Shelters should not be located near hazardous or flammable materials.
- o Two exits should be provided, located as far apart as possible. Debris may block an exit, and an alternative escape exit should be available.
- o A minimum of 10 square feet of floor space and a minimum of 65 cubic feet of air volume should be provided per person.
- o Rather than one large shelter to house all of the key workers in an emergency, two or more smaller shelters should be built. This would greatly improve everyone's chances for survival, as a buddy system could be implemented and one group could help the other, should a problem arise.
- o Existing basement areas that are potentially available for upgrading and existing underground upgradable facilities must be capable of being cleaned and made habitable in 72 hours. The extent of cleaning necessary will depend upon the facility selected.
- o Tools and equipment to aid in exiting the shelter: blocks and jacks to remove debris and roadblocks during evacuation and for rescue of people from other shelters, as necessary.

### Fully Equipped Shelter Criteria

In addition to meeting the general criteria, a fully equipped shelter should contain the following:

- o Sufficient life support supplies adequate for a minimum two-week stay time. A detailed list is presented under the stocking and management section, Step 6.
- o Ventilation equipment adequate to supply at least 3 cubic feet per minute per person. (Larger air flows up to 40 cfm may be required in the hot, humid areas of the country.) Equipment should operatable by hand.
- o Radiation monitoring equipment.
- o Communication equipment.
- o Sleeping facilities.
- o Firefighting equipment.
- o Emergency power system.

A sketch of a typical fully equipped shelter is shown in Figure 1.

A short-term, or austere, shelter should contain:

- o Escape vehicles, either in or near the shelter, protected to 40 psi.
- o Minimal life support supplies.

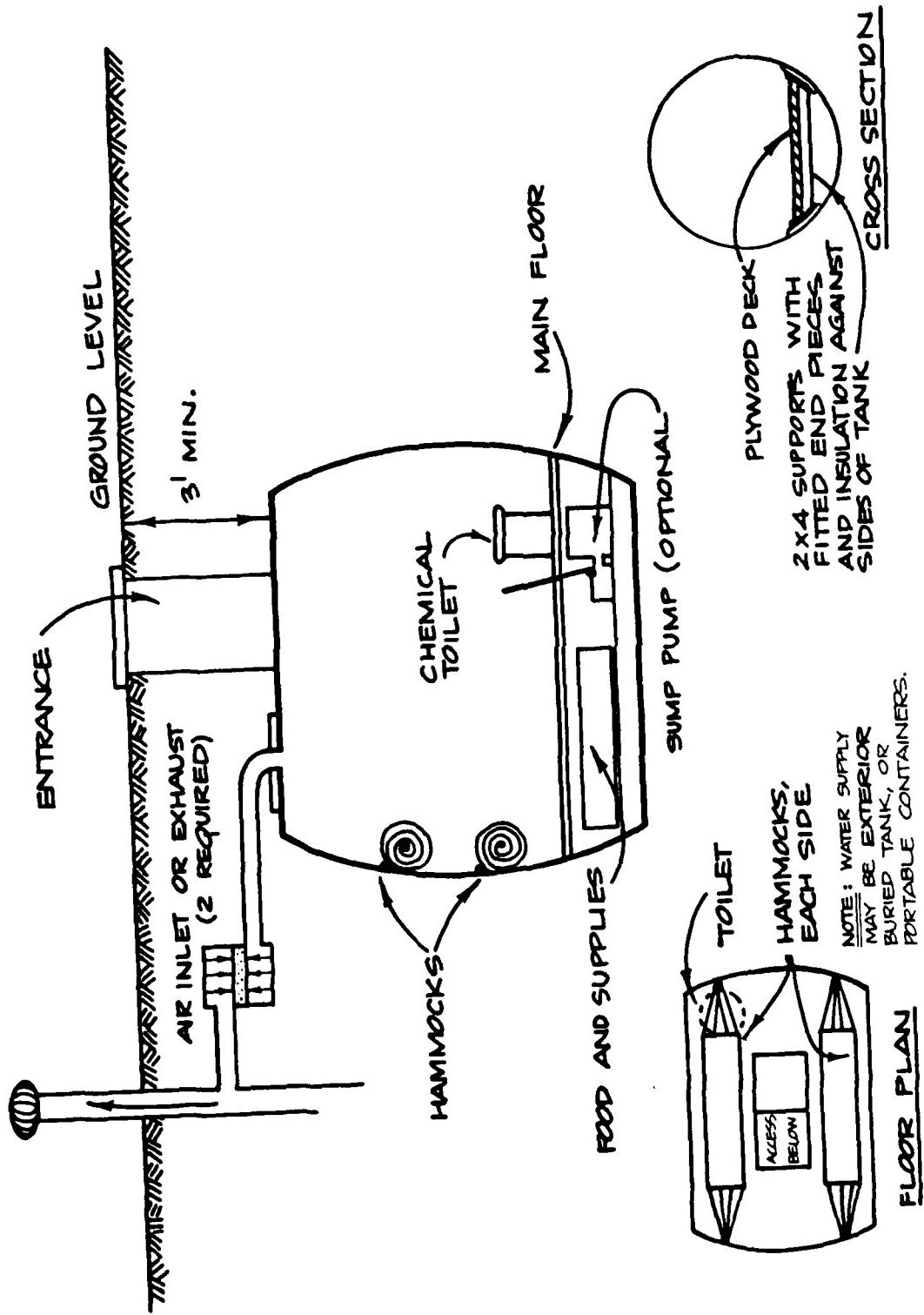


Fig. 1. Typical Equipped Shelter.

### **STEP 3: Survey Existing Structures for Upgrading**

The most desirable and economical shelters in terms of resources and manpower are those that can be found in existing structures at or close to the work site, and these should be surveyed first. Choose two or more smaller shelters over one large one, if that option is available. This will enable one group to help the other, should a problem arise.

The criteria specify **underground structures**. Because of blast-induced soil pressures, only those basements with reinforced concrete walls are considered adequate. In most cases these will be found in structures that were built for heavy industrial use (designed for 150 to 250 psf) under building code requirements that prevailed at the time. If you have no underground structure or basement -- skip to Step 4 (page 22).

Candidate shelters will need to be upgraded. This generally will consist of reinforcing the floor slab above the basement (discussed immediately below) and providing blast-proof closures (discussed in Step 5). Shelters will also need to be equipped with the life support systems discussed in Step 6.

#### **Upgrading of Floor Slabs.**

Seven reinforced concrete construction types have been found to be upgradable. The upgrading techniques shown in the following pages are designed to upgrade the various construction types to withstand 40 psi blast loadings. The categories for the types of construction are according to type of floor slab:

<b>Two-Way Slabs</b>	<b>One-Way Slabs</b>
Flat plate and flat slabs	One-way joist and one-way slab, beam and girder
Waffle slabs	Double tee
Slab and girder	Hollow-core <b>One-Way Slab and Girder</b>

The upgrading techniques are of two types depending on the type of construction:

- o Post shores (compare page 9 with page 8)
- o Post and beam supports (compare page 15 with page 14)

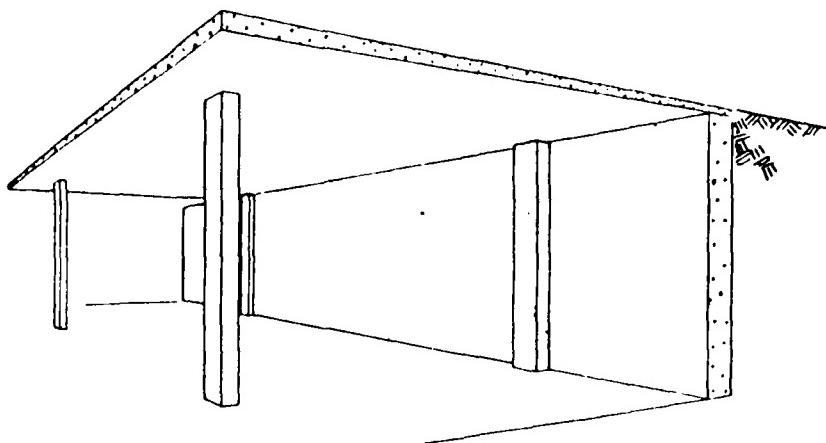
For either system, supports should be added at one-quarter of the span in both directions -- width and length. For example, if the span (distance between columns) is 20 feet, the supports are to be placed 5 feet on centers, and if the span is 40 feet, the supports are to be placed 10 feet on centers. The space between shores is greater for longer spans, thus fewer shores per shelteree are required. Long-span basement areas are expected to be few, however. A shelter requiring very close support shoring is best used only for short stay-time shelters.

The resources used in the upgrading procedures consist of:

- o Steel and wood posts
- o Steel beams

**Wood beams cannot be used for upgrading to 40 psi because of stress limitations, which cause crushing of the beam fibers.**

Upgrading details are shown in Appendix A.



## Flat Plate and Flat Slab

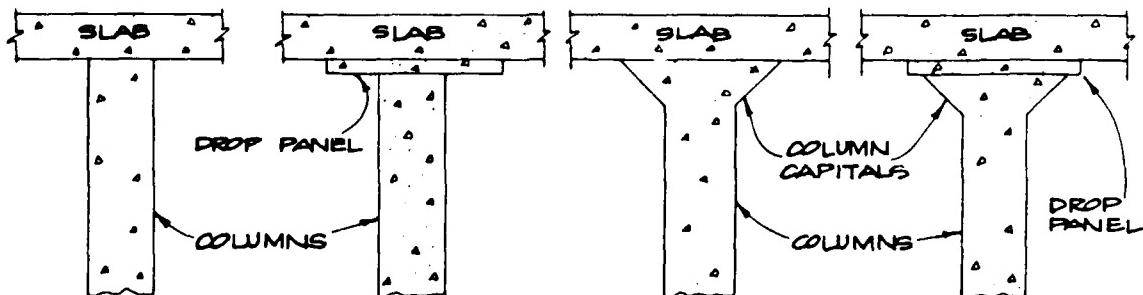
### Characteristics and Construction Details

Concrete slabs are 8 inches to 12 inches thick without other detailed engineering or construction features.

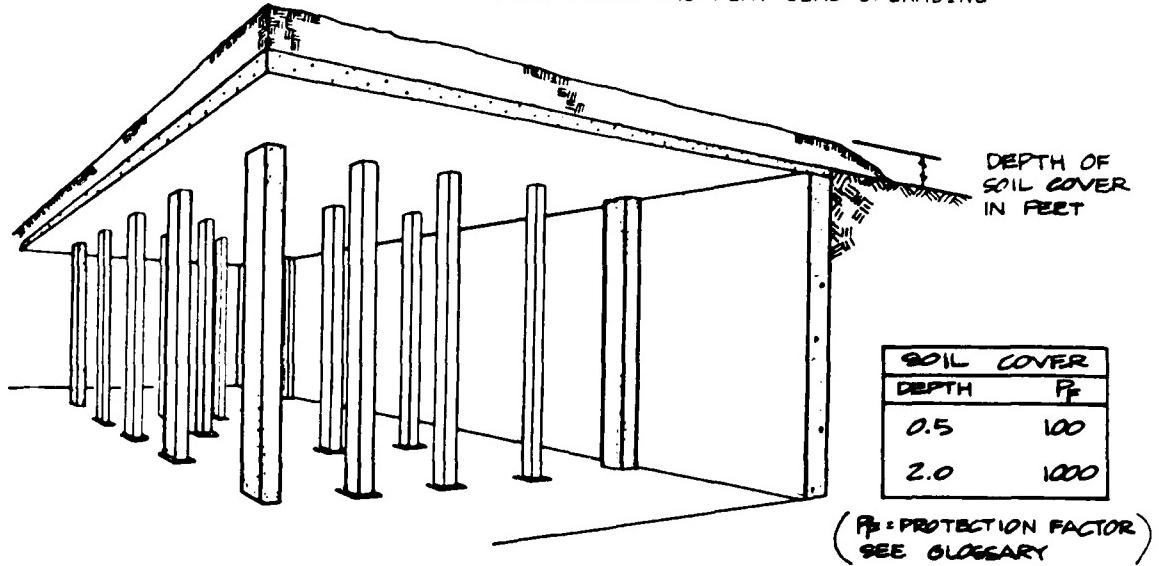
Columns are concrete and are constructed integrally with the floor slabs in a variety of ways as shown below. Columns may be round or square, and details refer to interior columns and columns constructed adjacent to a concrete wall.

Drop panels are usually 2 to 5 inches thick, and column capitals vary in height.

Spans between columns normally vary from 16 to 30 feet.

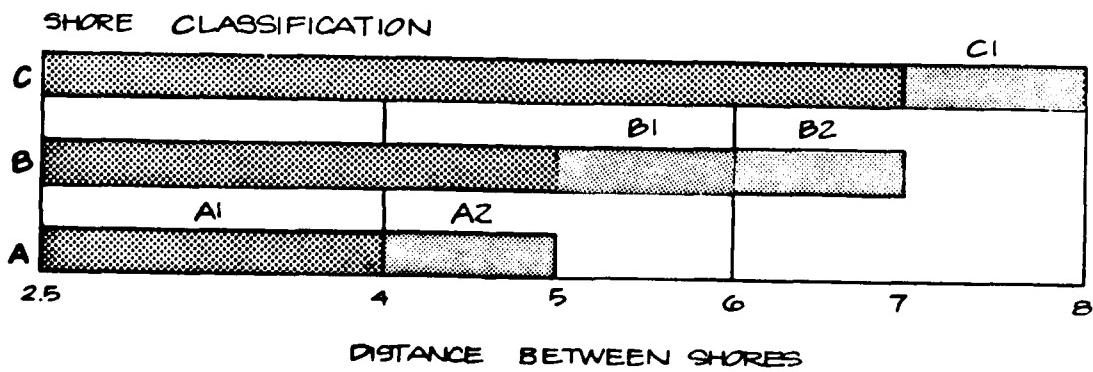


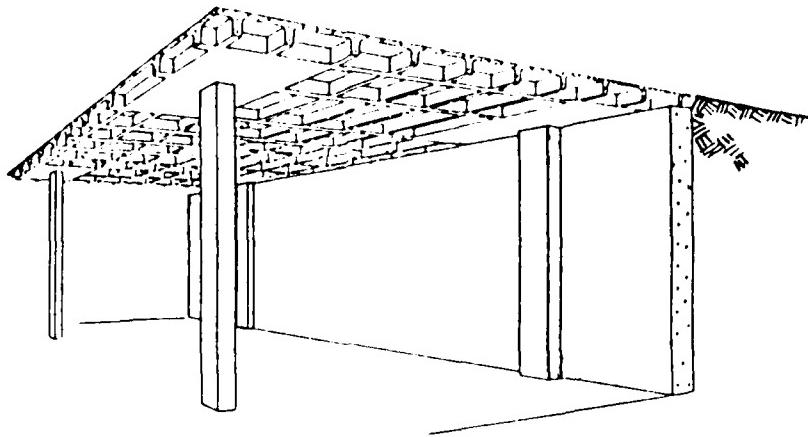
## FLAT PLATE AND FLAT SLAB UPGRADING



### Shoring

The recommended method for shoring flat plate and flat slabs is to use post shores, as shown in the sketch above. For shore classification see spacing chart below, and for types of shores refer to pages A-3 to A-5. Maximum unshored distance should not exceed 1/4 of the span.





## Waffle Slab

### Characteristics and Construction Details

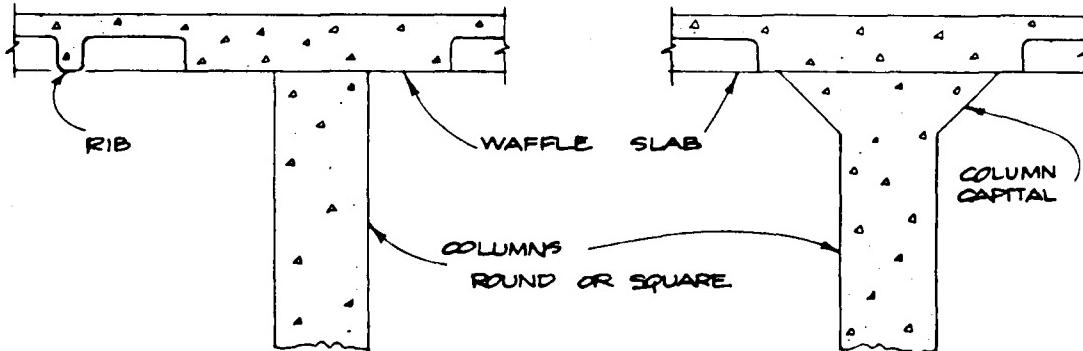
Concrete deck and ribs are cast as one unit. The industry standard waffle forms are 19 inches square and 30 inches square. Top slab thickness is usually 3 inches or  $4\frac{1}{2}$  inches.

Ribs are 5 inches thick for 19-inch waffle forms, and vary in depth from 6 to 12 inches.

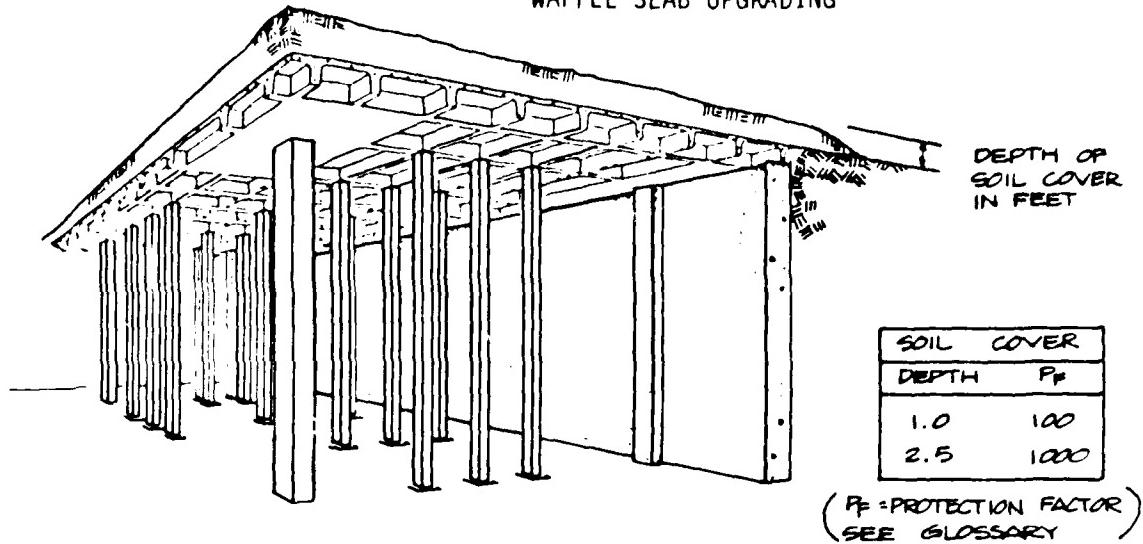
Ribs are 6 inches thick for 30-inch waffle forms, and vary in depth from 8 to 20 inches.

A non-waffled section is constructed around each column.

Columns are concrete and are constructed integrally with the waffle slab. Typical details are shown below. Spans between columns normally vary from 15 to 36 feet.

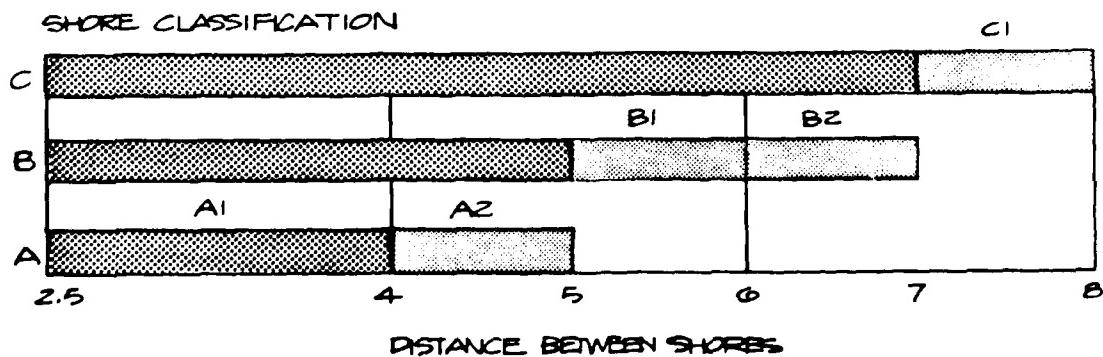


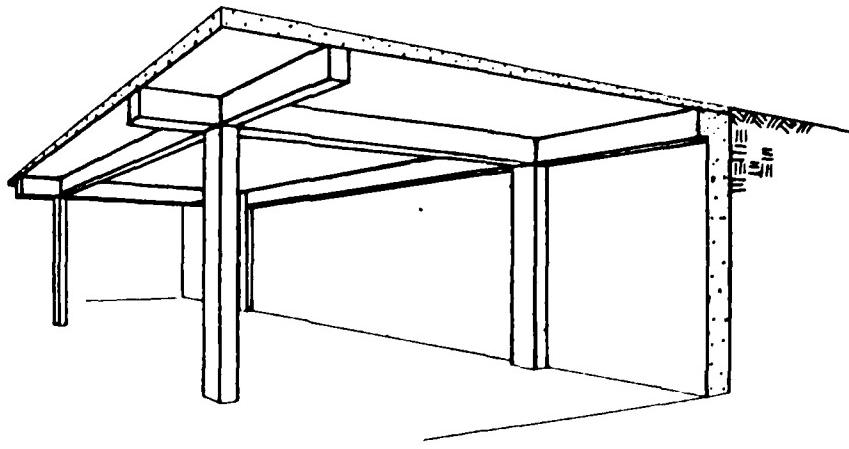
## WAFFLE SLAB UPGRADING



### Shoring

The recommended method for shoring waffle slabs is to use post shores, as shown in the sketch above. For shore spacing, the posts must be placed at the intersection of the waffle ribs. Thus, for 19-inch waffles, the posts will be at multiples of 2 feet, and for 30-inch waffles, the posts will be at multiples of 3 feet. For shore classification see spacing chart below, and for types of shores, refer to pages A-3 to A-5. Maximum unshored distance should not exceed 1/4 of the span. More shores may be required for the waffle slab because of post shore location restrictions.





## Two - Way Slab & Girder

### Characteristics and Construction Details

Concrete slabs are 8 to 12 inches thick, and girders are cast with the slab.

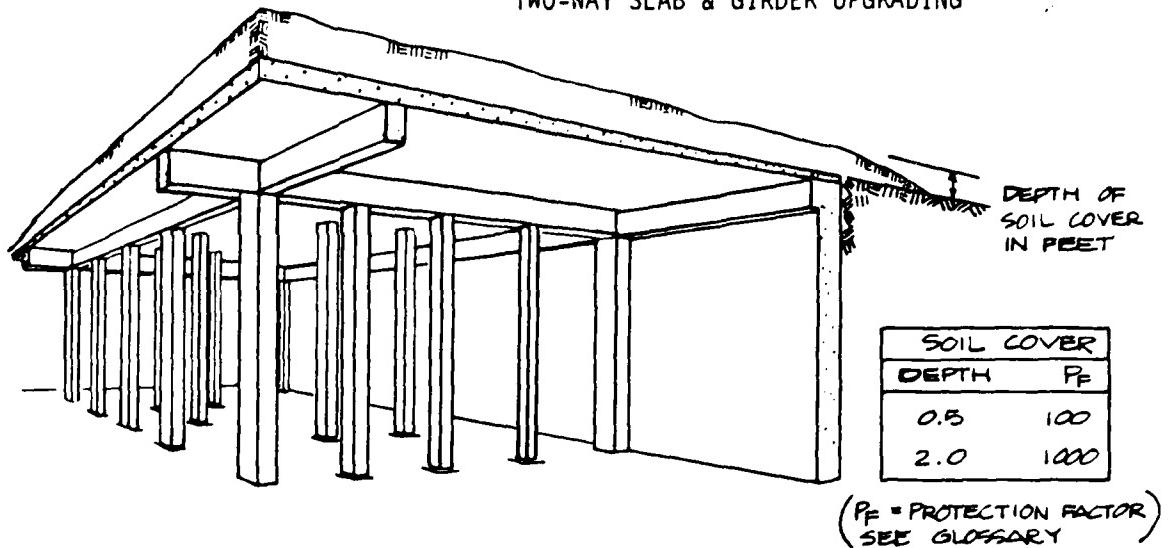
Columns are concrete, and are constructed integrally with the girders.

Columns are generally square or rectangular.

Girders are usually 12 inches wide or more and may be up to 36 inches deep in heavy, long-span structures.

Span between supports normally varies from 16 to 30 feet.

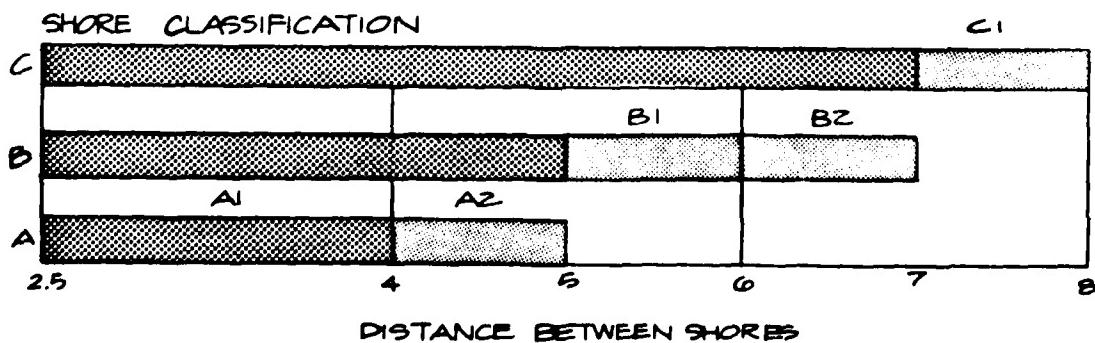
## TWO-WAY SLAB & GIRDER UPGRADING

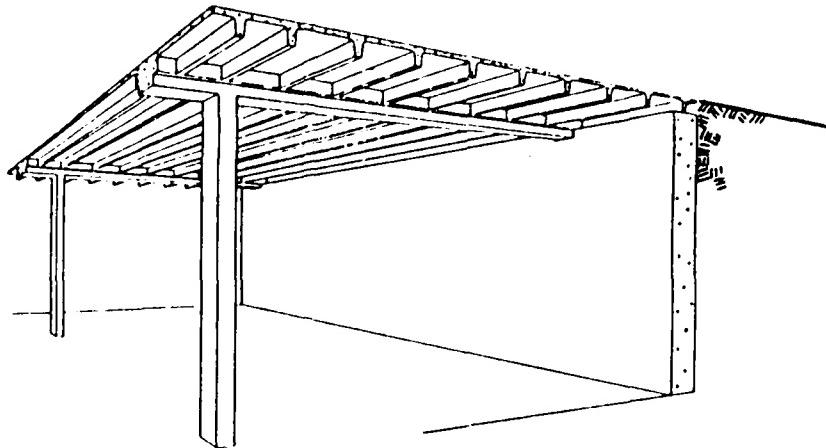


### Shoring

The recommended method for shoring two-way slab and girder is to use post shores, as shown in the sketch above. Two lengths of shores must be provided (for shoring the beams and the slab, respectively).

For shore classification see spacing chart below, and for types of shores, refer to pages A-3 to A-5. Maximum unshored distance should not exceed 1/4 of the span.





## One-Way Joist & One-Way Slab, Beam & Girder

### Characteristics and Construction Details

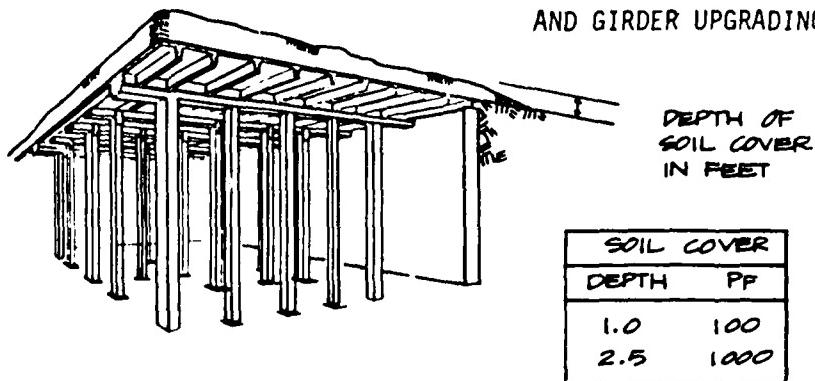
Concrete slabs are poured monolithically with joist ribs or beams, and girders.

Slabs for one-way joists are  $3\frac{1}{2}$  to 4 inches thick. Joist ribs vary from 5 to 7 inches thick, from 10 to 20 inches deep, and are tapered. Spacings between ribs are usually 20 inches or 30 inches. Span length varies from 16 to 26 feet.

Slabs used in slab, beam and girder construction are generally 6 inches and thicker. Beams are generally not less than 10 inches wide, and girders not less than 12 inches wide. Depth of beams and girders vary and generally are not greater than 30 inches. Spans vary from 20 to 36 feet.

Columns are generally rigidly tied to girders and can be rectangular or square.

ONE-WAY JOIST & ONE-WAY SLAB, BEAM  
AND GIRDER UPGRADING

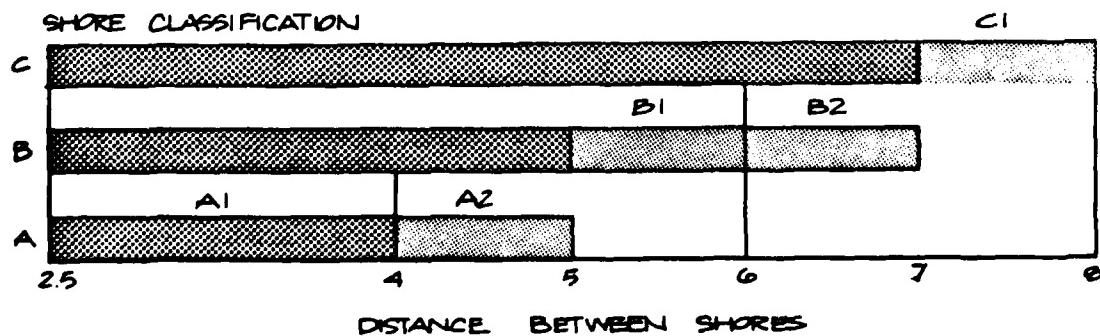


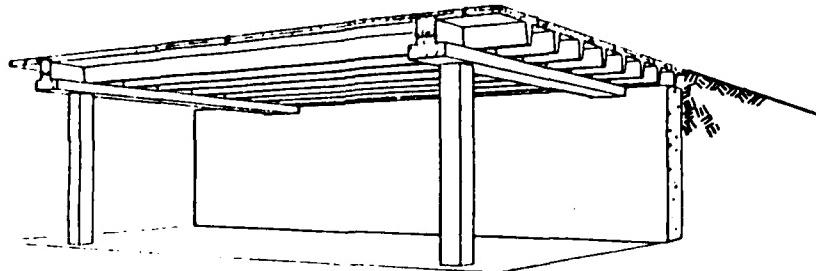
( PF = PROTECTION FACTOR )  
SEE GLOSSARY

Shoring

The recommended method for shoring one-way joist and one-way slab, beam and girder is to use post and beam shores. It should be noted that posts and beam shores are to be placed under the joist and beam portions of the basement area. Post shores must be used under the main girder members.

For shore classification see spacing chart below, and for types of shores refer to pages A-3 to A-6. Maximum unshored distance should not exceed 1/4 of the span.





## Double Tee

### Characteristics and Construction Details

Concrete double tee construction are precast units, transported and erected at the site.

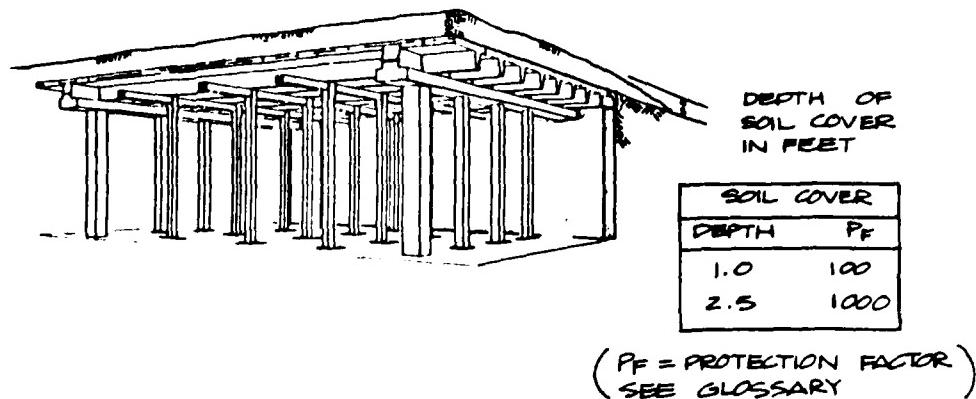
Girder beam supports are often inverted tee beams set in place, or cast with the columns.

Slab thickness usually is not less than 4 inches. Thicker slabs occur with deep, widely spaced tee stems.

Stems normally range from 16 to 32 inches deep, and double tee spans range from 18 to 30 feet.

Columns are usually square or rectangular and are usually tied to the girders.

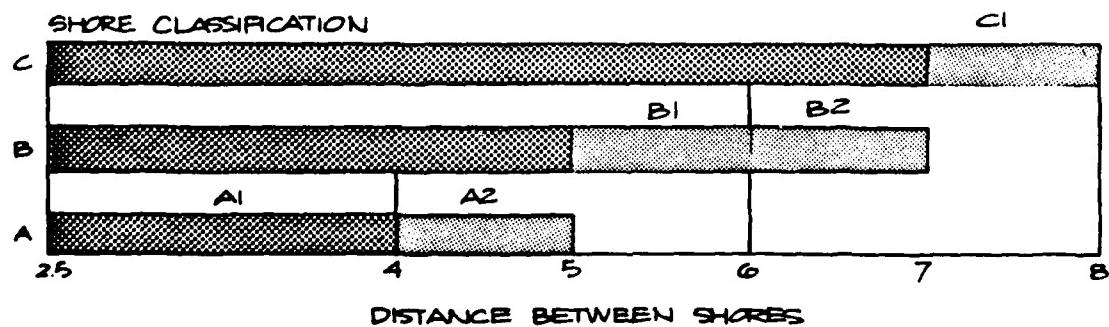
## DOUBLE TEE UPGRADING

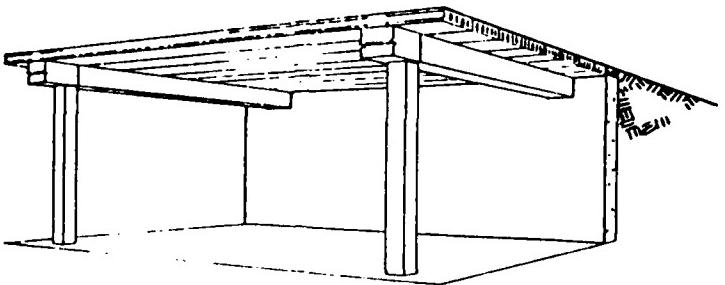


### Shoring

The recommended method for shoring double tee concrete construction is to use post and beam shores, with post shores under the supporting girders.

For shore classification see spacing chart below, and for types of shores refer to pages A-3 to A-6. Maximum unshored distance should not exceed 1/4 of the span.





### Concrete Hollow - Core

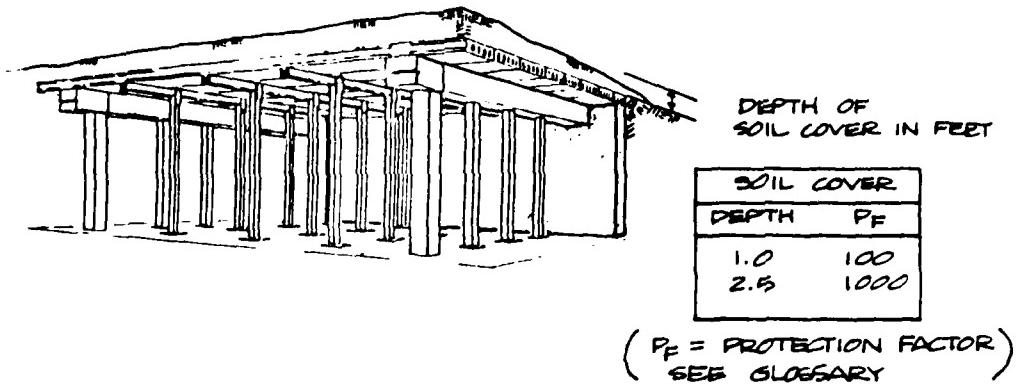
#### Characteristics and Construction Details

Concrete hollow-core construction is fabricated as precast slab units, with reinforcing in the longitudinal direction only. Individual slabs are placed side by side, and the deck is usually surfaced with a thin layer of concrete. Slab thickness is usually 8 to 10 inches.

The slabs are supported on girders and columns. The girders may be precast or cast-in-place. Columns may also be precast or cast-in-place.

Hollow-core spans normally range from 18 to 28 feet.

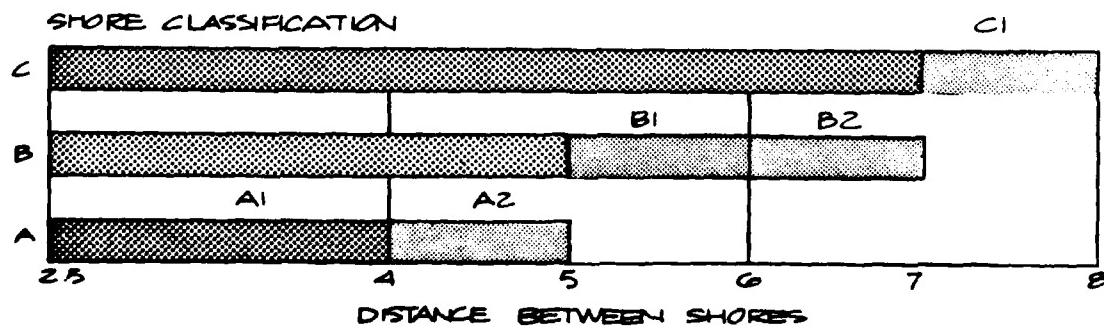
## CONCRETE HOLLOW-CORE UPGRADING

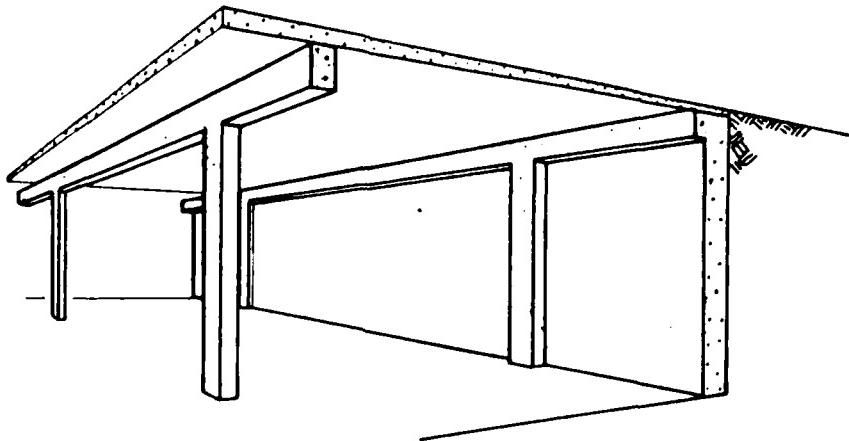


### Shoring

The recommended method for shoring hollow-core construction is to use post and beam shores under the slabs, and post construction under the supporting girders.

For shore classification see chart below, and for types of shores, refer to pages A-3 to A-6. Maximum unshored distance should not exceed 1/4 of the span.





## One-Way Slab and Girder

### Characteristics and Construction Details

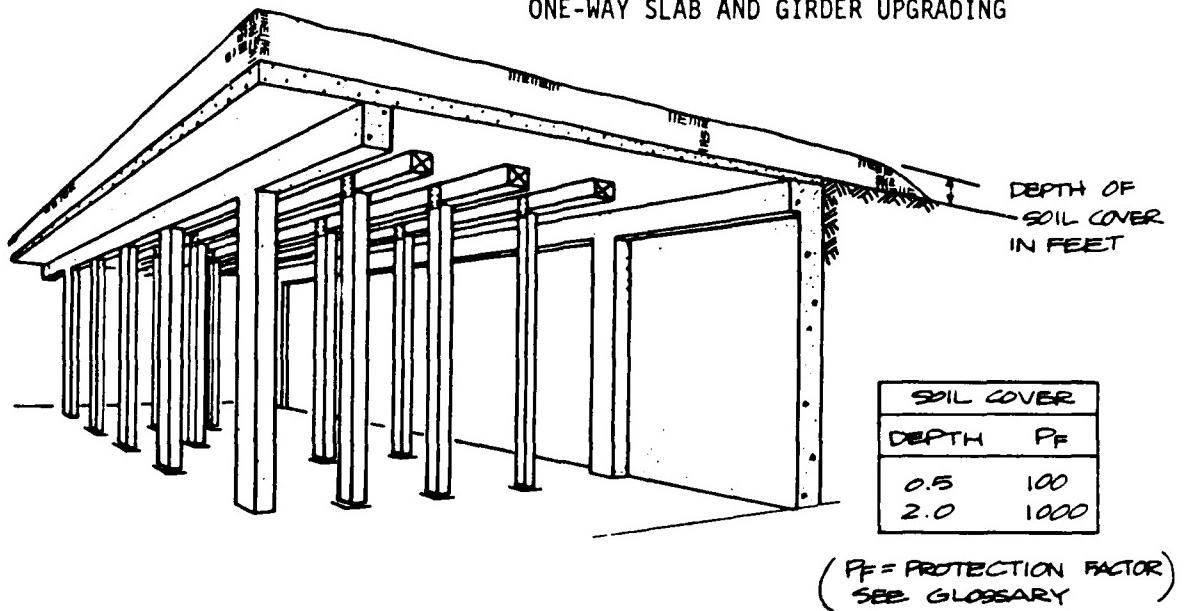
Concrete slabs are 8 to 12 inches thick, and girders are cast with the slab.

Columns are concrete and are constructed integrally with the girders. Columns are generally square or rectangular.

Girders are normally 12 inches wide or greater, and may be up to 36 inches deep in heavy, long-span structures.

Spans between supports along the girders normally vary from 20 to 30 feet. The width between girders is usually one-half the span length or less.

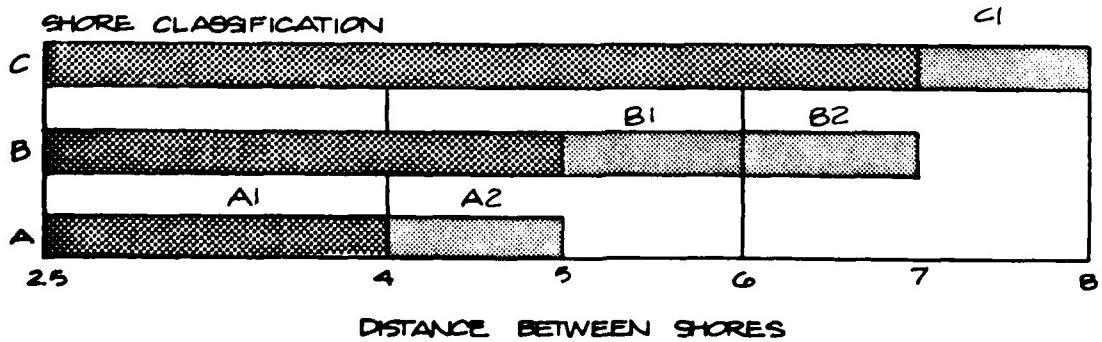
## ONE-WAY SLAB AND GIRDER UPGRADING



### Shoring

The recommended method for shoring one-way slab and girder is to use post and beam shores under the slab, as shown in the sketch above and post shores under the girder. Two lengths of shores must be provided for shoring the beams.

For shore classification see spacing chart below, and for types of shores refer to pages A-3 to A-6. Maximum unshored distance should not exceed 1/4 of the span.



#### **STEP 4: Survey Expedient Shelters for Upgrading**

Because of the limited number of existing structures that have been found to be upgradable, it will be necessary in many cases to use expedient shelters. There are many options that could be considered, including adapting onsite buried enclosures such as tanks, storm drains, utility vaults or alternatively, obtaining an enclosure that can be buried. Structures that can be buried and used as shelters include railroad cars, tanks, or specially designed shelters.

Expedient shelter options discussed here are as follows:

- Buried tanks
- Railroad cars
- Storm drain systems
- Other shelter types

Two expedient shelter checklists are provided at the end of the main text as an aid for implementing expedient shelters. These checklists are designed to assist the industry planner in shelter selection and upgrading.

The shelter options discussed herein are only a few of the potential possibilities for key worker shelters. Each plant superintendent and/or planner should survey his plant and immediate area for the best choices. The formation of mutual aid pacts with other nearby essential industries to develop key worker shelters jointly should also be considered.

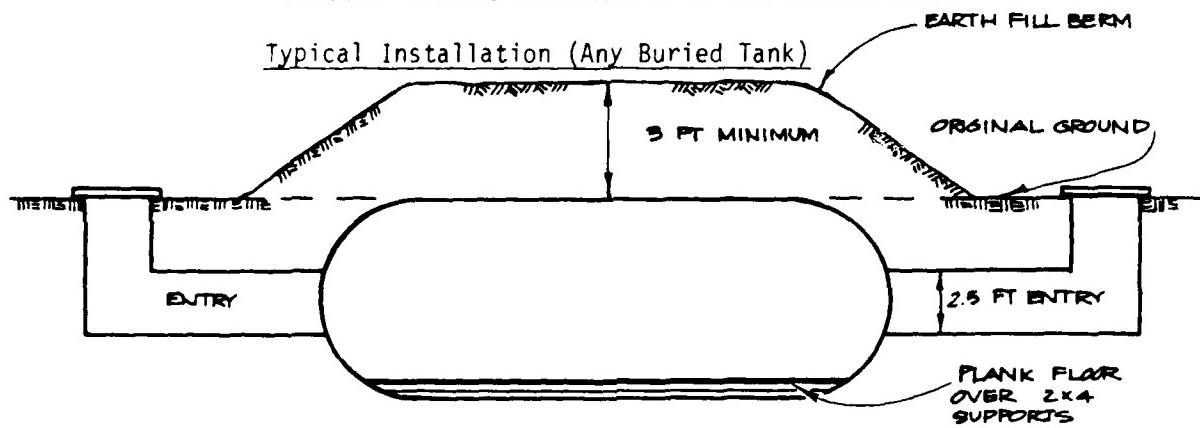
EXPEDIENT SHELTER FACT SHEET  
BURIED TANKS

Buried tanks provide ideal shelters and, dependent upon size, can be used for both long and short stay-times.

- (1) Pressure vessel type tanks, such as newly manufactured liquid propane or LNG type tanks, do not require upgrading.
- (2) Many other types (non-pressure) can be easily upgraded. Detailed upgrading schemes have not yet been developed.

Limitations

- (1) Do not use tanks that have been used previously for fuel storage, toxic chemicals, or other hazardous materials.
- (2) Do not bury tanks in areas where high ground water is present, as the tanks may rise out of the ground owing to fluid uplift pressures.
- (3) The number of people that can be sheltered in pressure vessels in most instances will not exceed ten.



Note: Entry can be fabricated using 30-inch diameter corrugated metal, concrete pipe, or wood framing. See section on closures.

## EXPEDIENT SHELTER FACT SHEET

### RAILROAD CARS

Certain types of railroad cars can provide ideal shelters without upgrading for 20 to 30 people for long and short stay-times. The railroad car options discussed are limited to those fabricated of structural steel components, as described, and would not ordinarily require upgrading:

Rail tank cars

Hopper cars, both open and closed

Gondola type cars

#### Notes

- (1) All cars would have their undercarriages, couplers, and miscellaneous non-essential frame materials removed.
- (2) Rail tank cars have access hatches on the top. Thus, the cars could be buried upright or on their sides.
- (3) Closed hopper cars have two compartments, and thus, two separate shelters can be provided from one car. Cars could be buried upright or on their sides.
- (4) Open hopper cars can be buried upside down, and the hopper gate modified as a shelter entrance.
- (5) Gondolas can be buried upside down, and access may then be provided through the side walls.
- (6) Heavy crane or other lifting equipment is required to place cars in excavation.

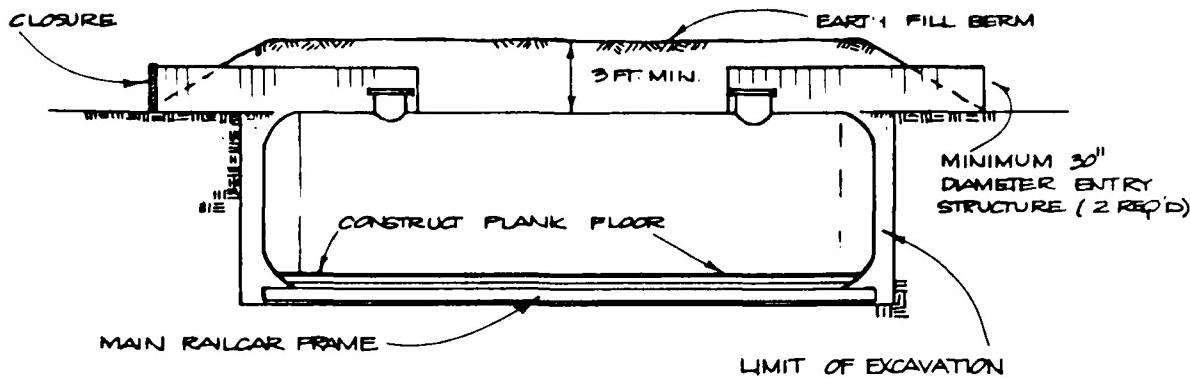
Advantages of Implementing Railcars

- (1) Railcar types suggested for expedient shelters are all constructed of steel sheet plate with heavy steel frames, hatches, and reinforcing.
- (2) Railcar bodies are readily available from car dismantler companies.

TYPICAL RAILCAR ANNUAL RETIREMENT

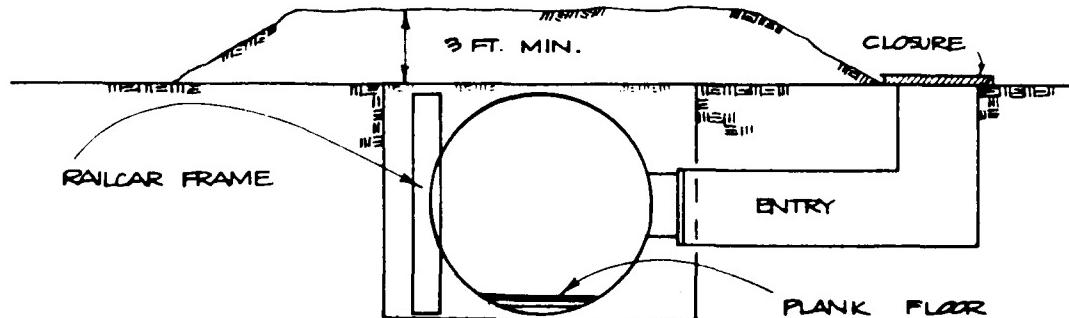
Type of Car	Total No. of Cars Retired Annually	10% of Car Bodies Usable Without Repair	20% of Car Bodies Estimated Repairable	Total Potential Car Bodies Usable
Tanks	128	13	26	39
Hopper (closed)	11,382	1,138	2,276	3,414
Hopper (open)	23,271	2,327	4,654	6,981
Gondolas	12,559	1,256	2,512	3,768
TOTALS	47,340	4,734	9,468	14,202

Details of railcars buried as expedient shelters are shown on the following pages.

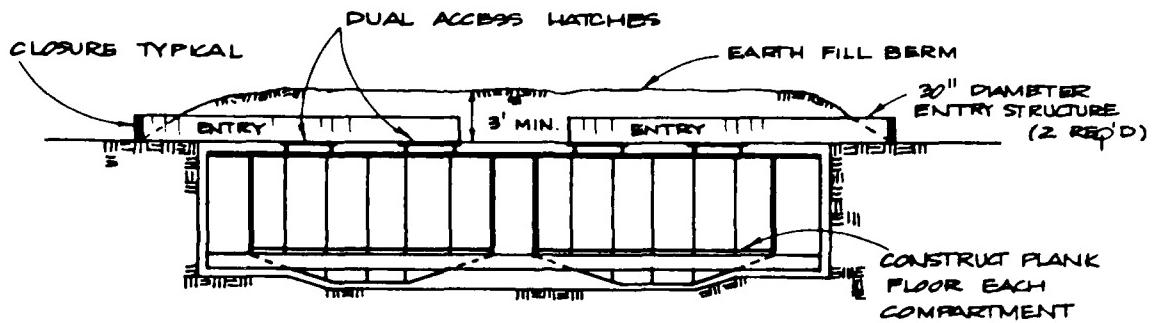


Typical Buried Railroad Tank Car

- Notes:
- (1) Railcar undercarriage and frame are removed from tank to the extent possible; otherwise bury with frame components.
  - (2) Interior floor may be constructed with plywood and 2-inch dimension lumber for framing.
  - (3) Access to car hatches may be fabricated with 30-inch corrugated metal, including elbow at hatch. A wood-framed entry may also be used. It may be necessary to remove hatches, to provide access.
  - (4) Entry structure can also be used for ventilation.
  - (5) Temporary closures are required for blast protection.
  - (6) Tank must be steam cleaned prior to burial. DO NOT USE tank cars that were previously used for fuel storage, toxic chemicals, or other hazardous materials.

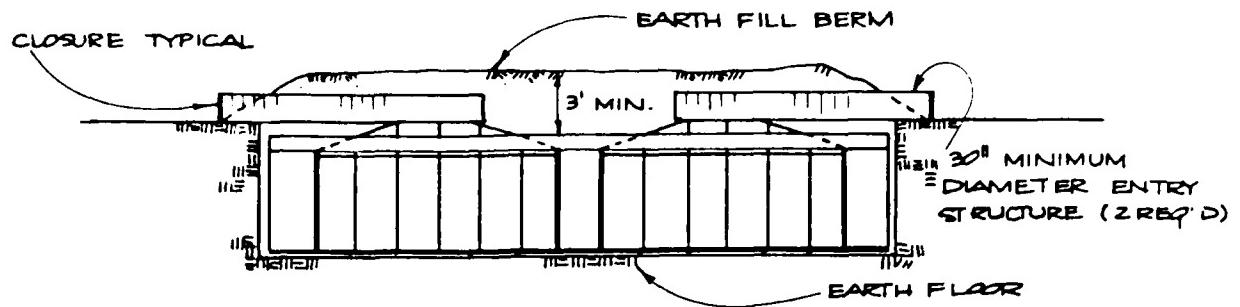


Typical Buried Railroad Tank Car – Alternate Entry Configuration (On Side)



Typical Buried Closed Hopper Car

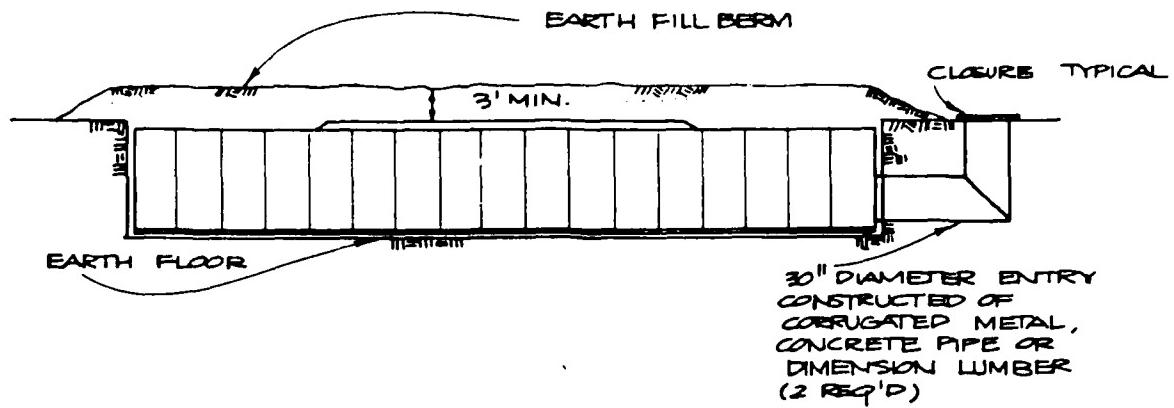
- Notes:
- (1) Railcar undercarriage and miscellaneous frame components to be removed prior to burial.
  - (2) Interior of car must have floor constructed over sloped hopper bottoms. Area below floor to provide shelter supply storage.
  - (3) Access to hatches to be fabricated of 30-inch metal pipe or wood framed. Double entry to compartment hatches for ventilation is recommended.  
Alternate hatch can be provided through side of car.
  - (4) Temporary closures are required for blast protection.
  - (5) Hoppers to be cleaned prior to burial.



Typical Buried Open Hopper Car (Upside Down)

Notes:

- (1) Railcar undercarriage and miscellaneous frame components are removed prior to burial.
- (2) Burial is upside down; earth floor is proposed; wood or other floor optional.
- (3) Access is through hopper bottoms, or alternatively, through side of car.
- (4) Temporary closures on entry are required for blast protection.
- (5) Hoppers to be cleaned prior to burial.



Typical Buried Gondola Car – Upside Down

- Notes:
- (1) Railcar undercarriage and miscellaneous frame components are removed prior to burial.
  - (2) Burial is upside down; earth floor is proposed. Wood or other floor is optional.
  - (3) Access is proposed through end or sides of car.
  - (4) Temporary closures on entry are required for blast protection.
  - (5) Car interior to be steam cleaned prior to burial.

## EXPEDIENT SHELTER FACT SHEET

### STORM DRAINAGE SYSTEMS

Major storm drainage facilities and their components can provide shelter in key worker areas for long and short stay-times. Two components of a typical drainage system are analyzed for shelter purposes:

- o Storm drain manholes (short stay-time)
- o Major conduits - 5 feet and larger (long stay-time)

#### Notes

- (1) Manholes should be a minimum of 4 feet in diameter and 6 feet deep.
- (2) Manholes are often located in high volume street traffic areas and therefore, access to them may not be available in these locations. Manholes located in street medians, parking, or low-traffic areas may be more easily implemented.
- (3) Large closures are necessary at conduit ends to provide blast protection, and these closures probably cannot be fabricated in less than 72 hours without some preplanning.
- (4) All open drain inlets must be sandbagged to provide blast protection.
- (5) Some storm drainage conduits may have considerable depth of flow or be located in areas subject to tidal action, and thus should not be used for shelters.
- (6) To utilize storm drain conduits with a minimum depth of water flow may necessitate construction of false floor systems. (see Figs. 2 and 3).

## Advantages of Using Storm Drain System Components as Expedient Shelters

### Manholes (Short Stay-Time):

- (1) Storm drain manholes are numerous. On any major drainage system they are located from 500 to 1,000 feet apart.
- (2) They require no upgrading and are easily adapted to use as short stay-time one- or two-man shelters, with addition of a temporary wood floor and modifications to manhole lid closures.
- (3) Special ventilation equipment is not required, as ventilation naturally occurs through drain pipes at base of manhole.
- (4) If storm drains are not available near the plant, manhole sections, as shown in Figure 4, may be obtained from manufacturers, and one- or two-man shelters can be buried at the key worker site. For small key industries with fewer than five key workers, this may be a viable option.

### Major Conduits - 5 Feet And Larger (Long Stay-Time)

- (1) No radiation or fallout shielding is necessary because of depth of burial.
- (2) Ventilation equipment is not needed, as the systems have natural ventilation at all inlet locations. Fabrication of blast resistant closures must be implemented also.
- (3) Long drain systems are large enough to provide shelter for more than one industrial plant.

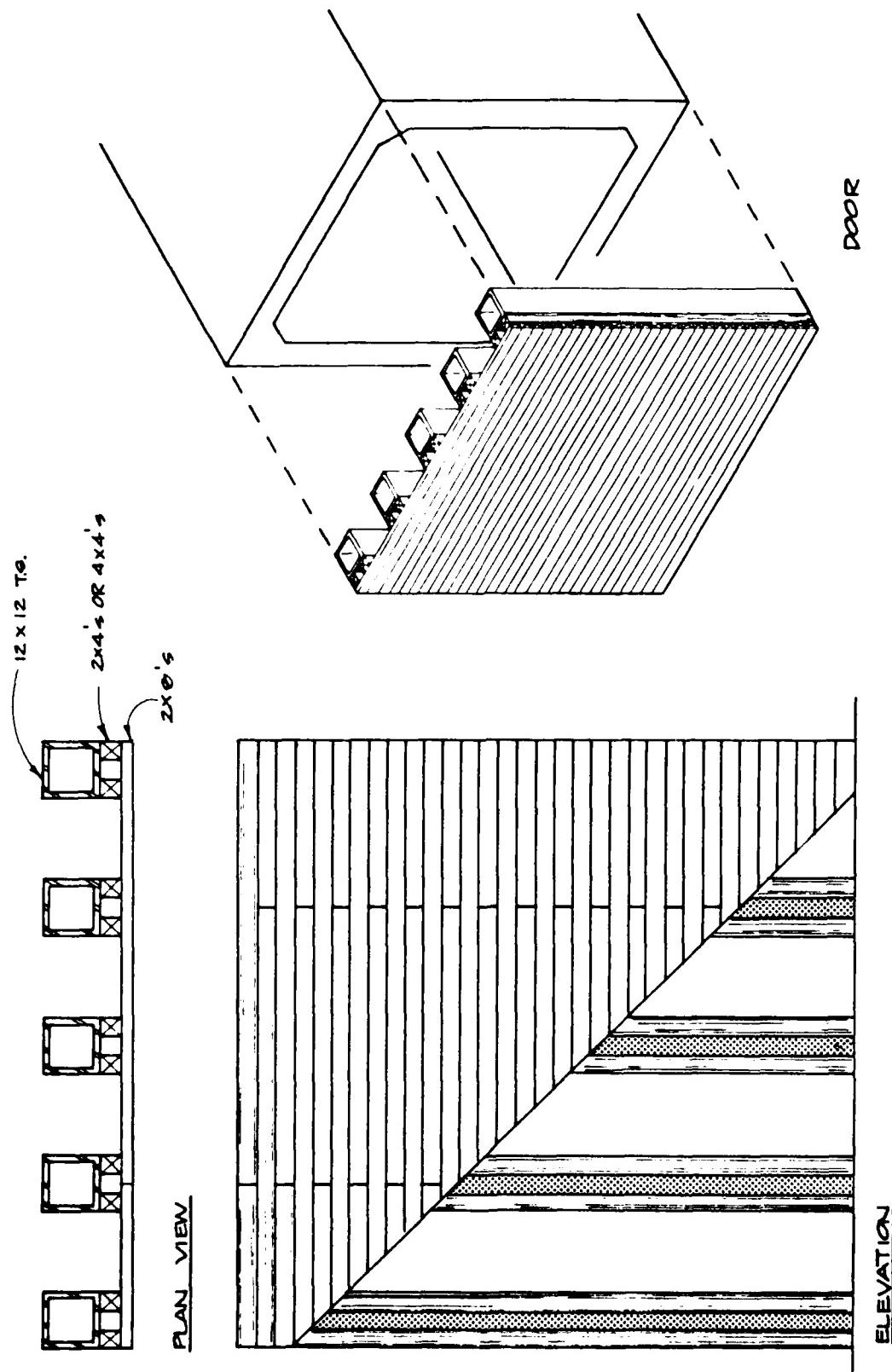


Fig. 2 . Typical Closure for a 10 ft by 10 ft Box Culvert For 40 psi.

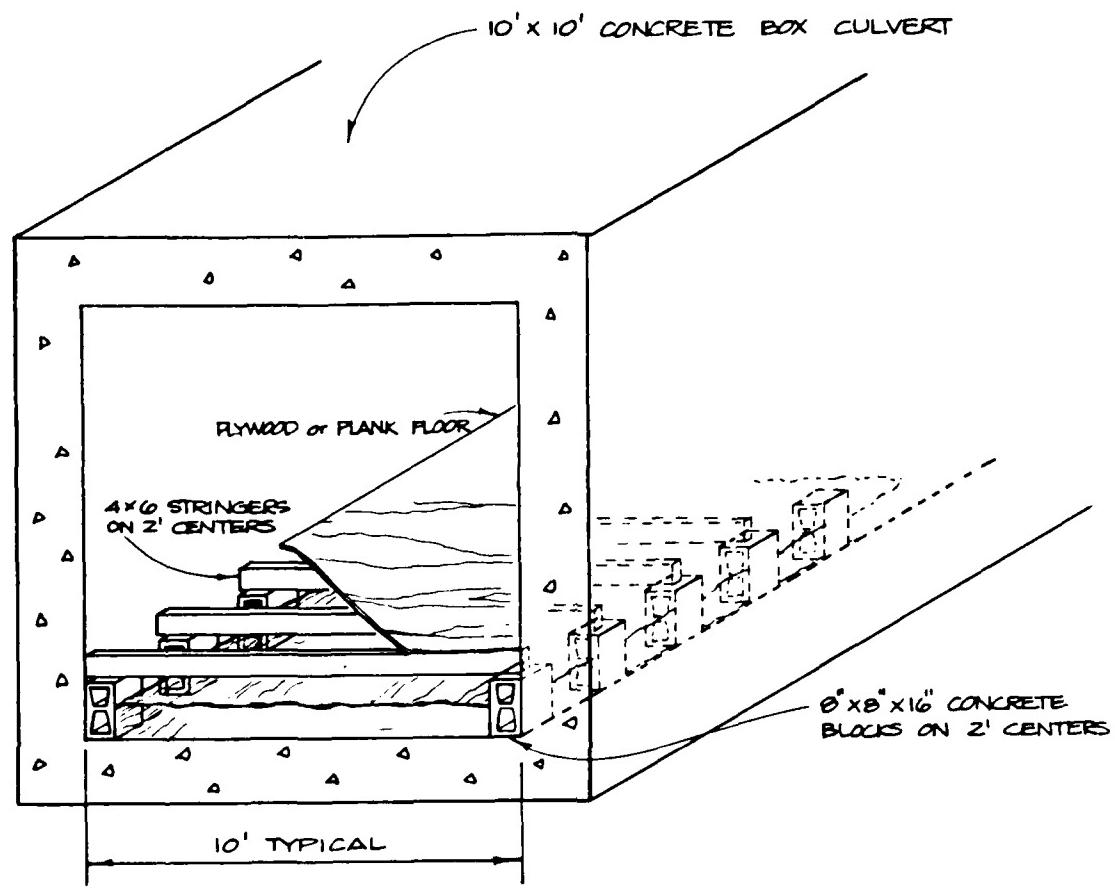


Fig. 3 Box Culvert Key Worker Shelter With Low-Flow False Floor.

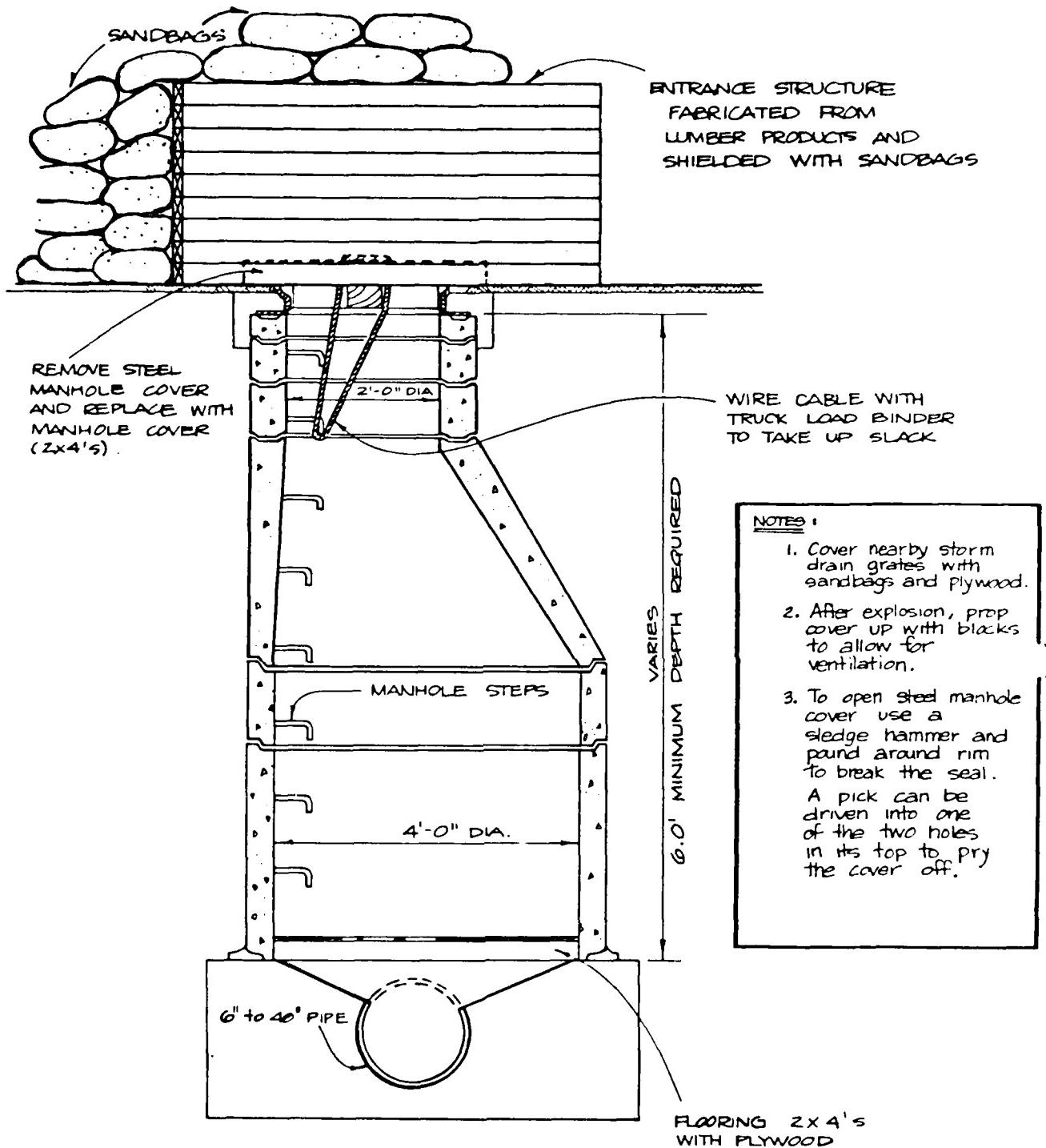


Fig. 4 . Key Worker Shelter in Storm Manhole.

## EXPEDIENT SHELTER FACT SHEET

### CONCRETE UTILITY VAULTS

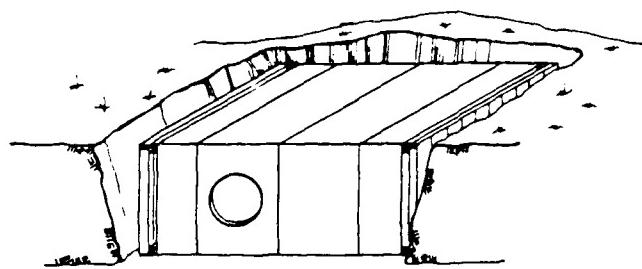
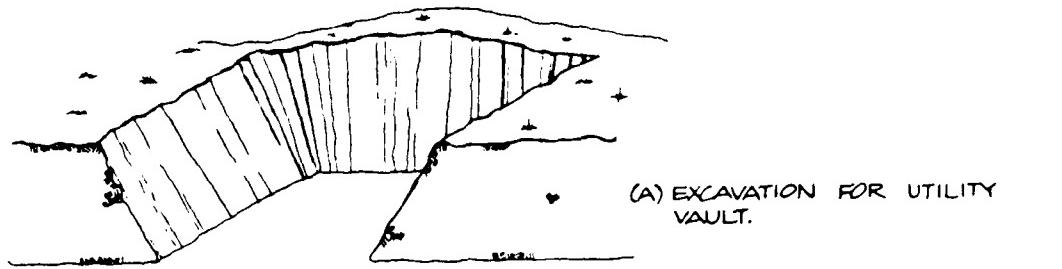
The adaptation of prefabricated underground utility vaults (the types used by telephone and electrical utilities) for key worker shelters is recommended as a valuable, practical, and easily implemented shelter option. The implementation of precast utility vault components for a shelter has been previously tested, and placement of a six-man vault and entrance structure, including covering the vault with earth radiation protection, required less than 10 hours using three men and heavy equipment.

Figures 5 and 6 show the burial of a utility vault shelter and the upgrading of various components.

### C.E.M.O. MARK II SHELTER

Previous experiments have been conducted to determine the use of a corrugated thin-walled fiberglass type cylinder structure for shelter purposes in the Dial Pack tests in 1971. The shelter survived a 40 psi blast with only minor structural damage, which was attributed to poor backfill operations. All equipment and supplies in the shelter were usable.

Figure 7 describes the C.E.M.O. Mark II shelter, a blast shelter developed by the Canadian Emergency Measures Organization.



(B) VAULT IN PLACE PRIOR TO BACKFILLING.

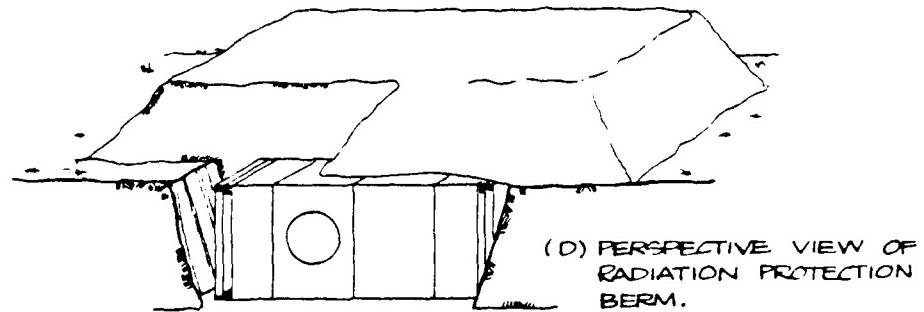
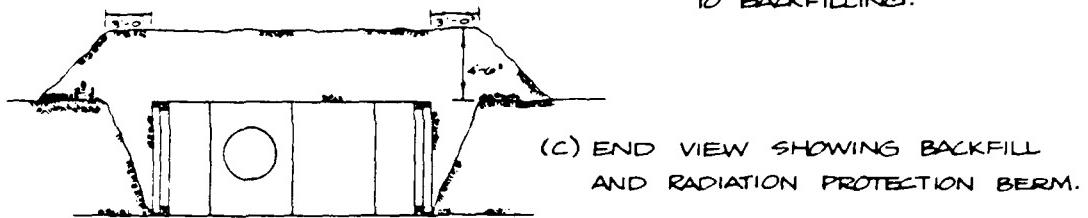


Fig. 5. Utility Vault Shelter.

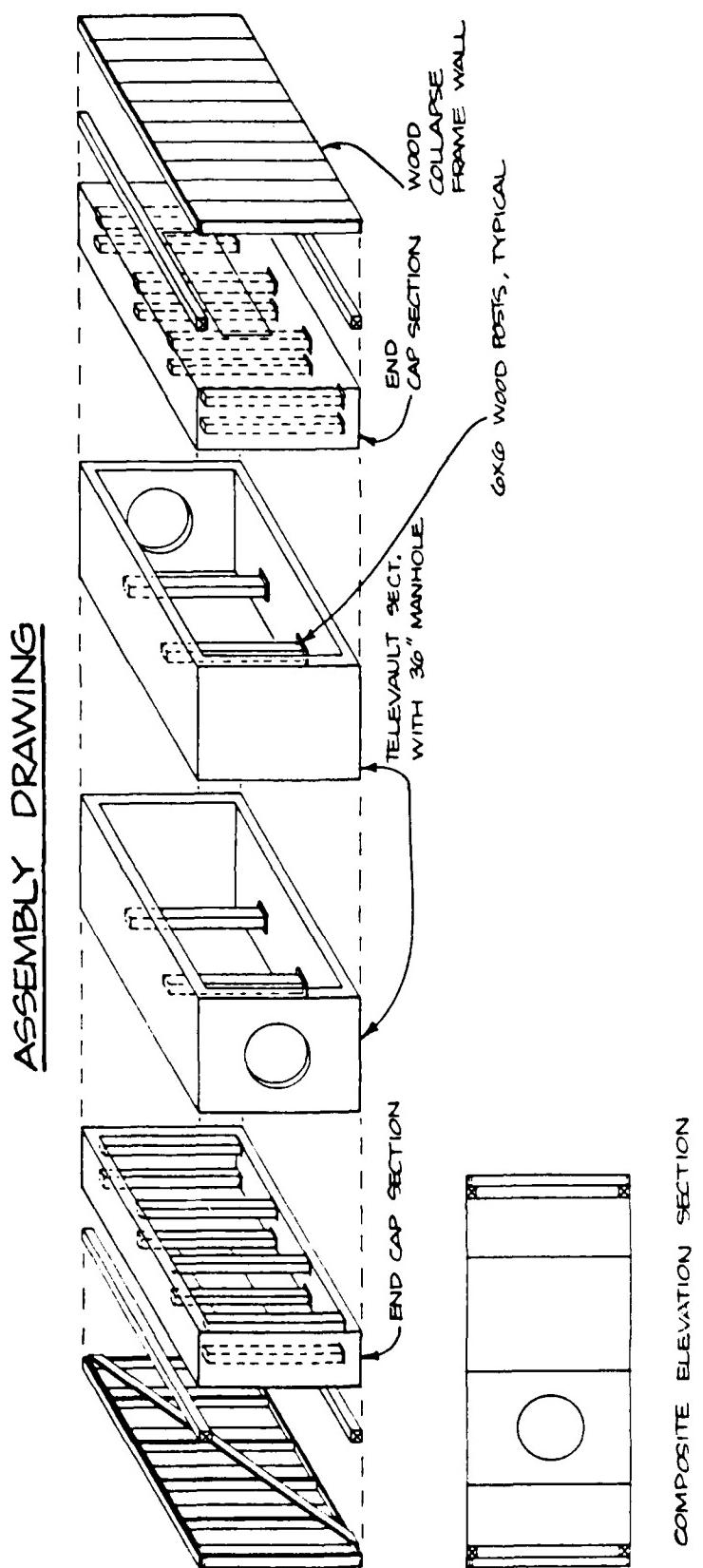


Fig. 6. Utility Vault Shelter Components, Depicting Upgrading Methods to Provide 40 psi Overpressure Protection.

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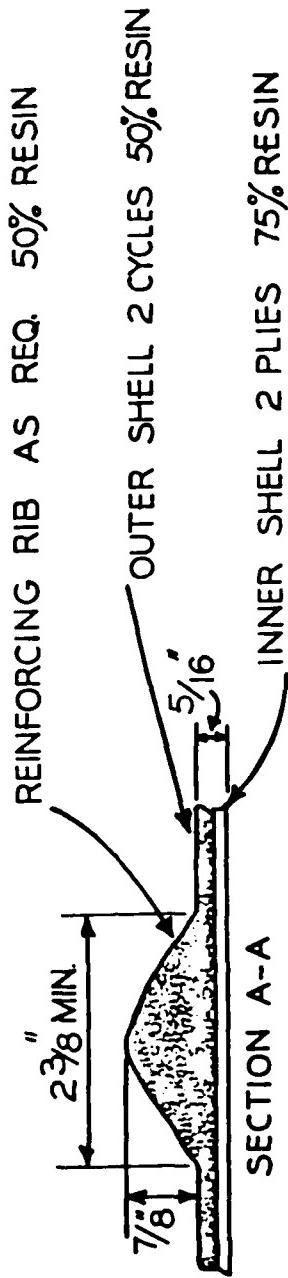
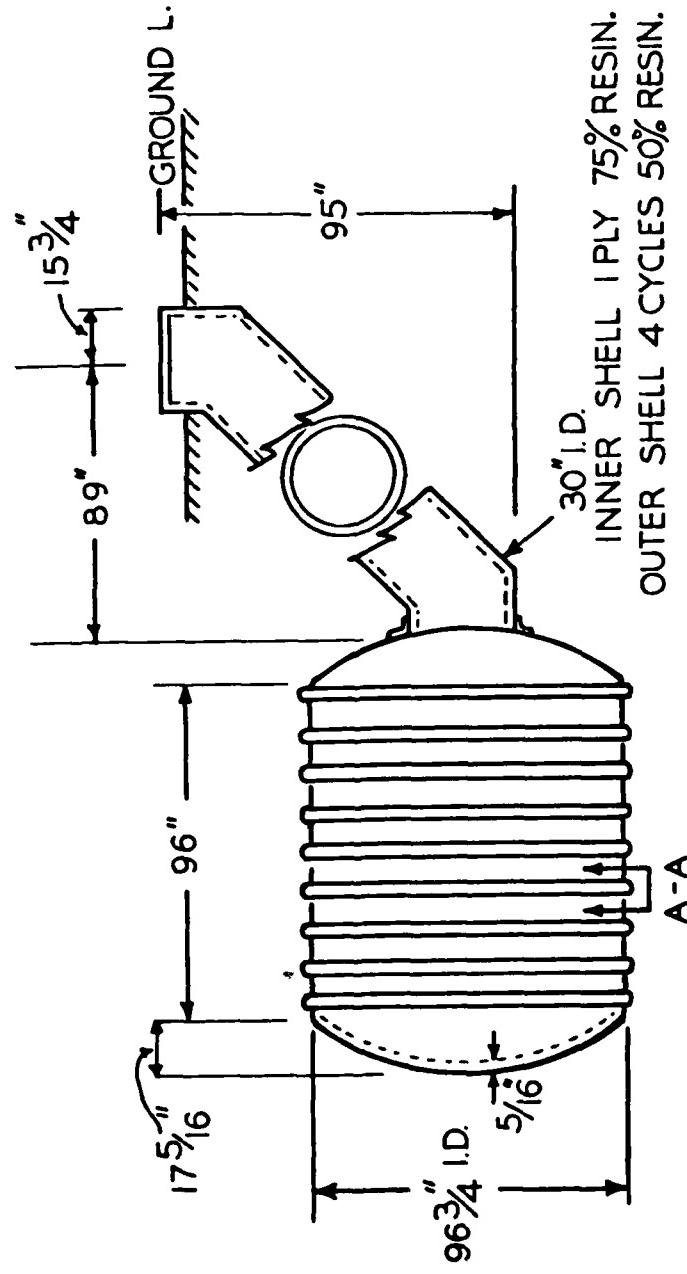


Fig. 7 C.E.M.O. Mark II Shelter Details.

## **STEP 5: Assess Shelter Closures and Access Alternatives**

Shelter entry structures and closures are key elements in the development of 40 psi blast-resistant, key worker shelter spaces. For the upgrading of existing basement areas, main concern is to ensure suitable blast-resistant closures for existing entryways and other openings, and development of acceptable access. Acceptable shelter entry will require a shelter entry structure.

### **Shelter Entry Structures**

The use of shelter entry structures is intended to provide a way into and out of the shelter that is both blast and radiation proof. Existing entries will not be. A typical wood construction entry structure that can be used is shown in Figure 8 and a suitable closure is shown in Figure 9.

As an alternative to wood construction, concrete pipe or corrugated metal pipe entry structures may also be fabricated. Figure 10 shows such a typical structure, and Figure 11 is a suitable closure for a circular entry structure.

### **Closures**

The majority of shelter spaces will require some form of closure in addition to entry closures. Any basement upgraded for a key worker shelter will probably have a stairway, windows, doors, ventilation ducts, or access openings.

These openings can be bridged by using a number of readily available materials, such as wood or steel. Examples of wood that may be used are fence posts, spare power poles (cut up), railroad ties, solid core doors, and wood beam and plank pieces. Steel plate and rolled beam sections may also be used. Table 1 (page 44) lists alternative materials that may be considered for closures.

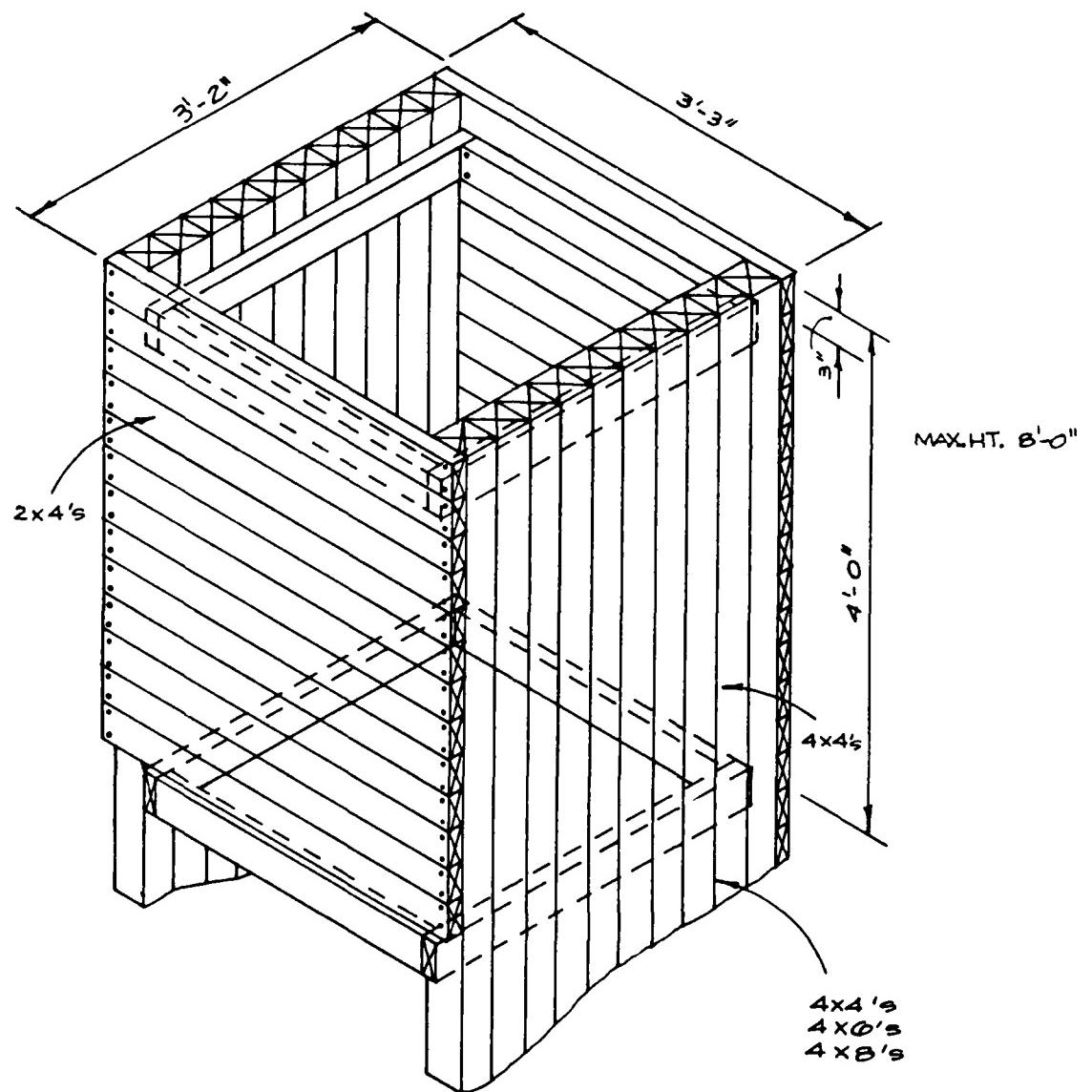


Fig. 8. 40 psi Entrance Structure to Key Worker Shelter (Wood Construction).

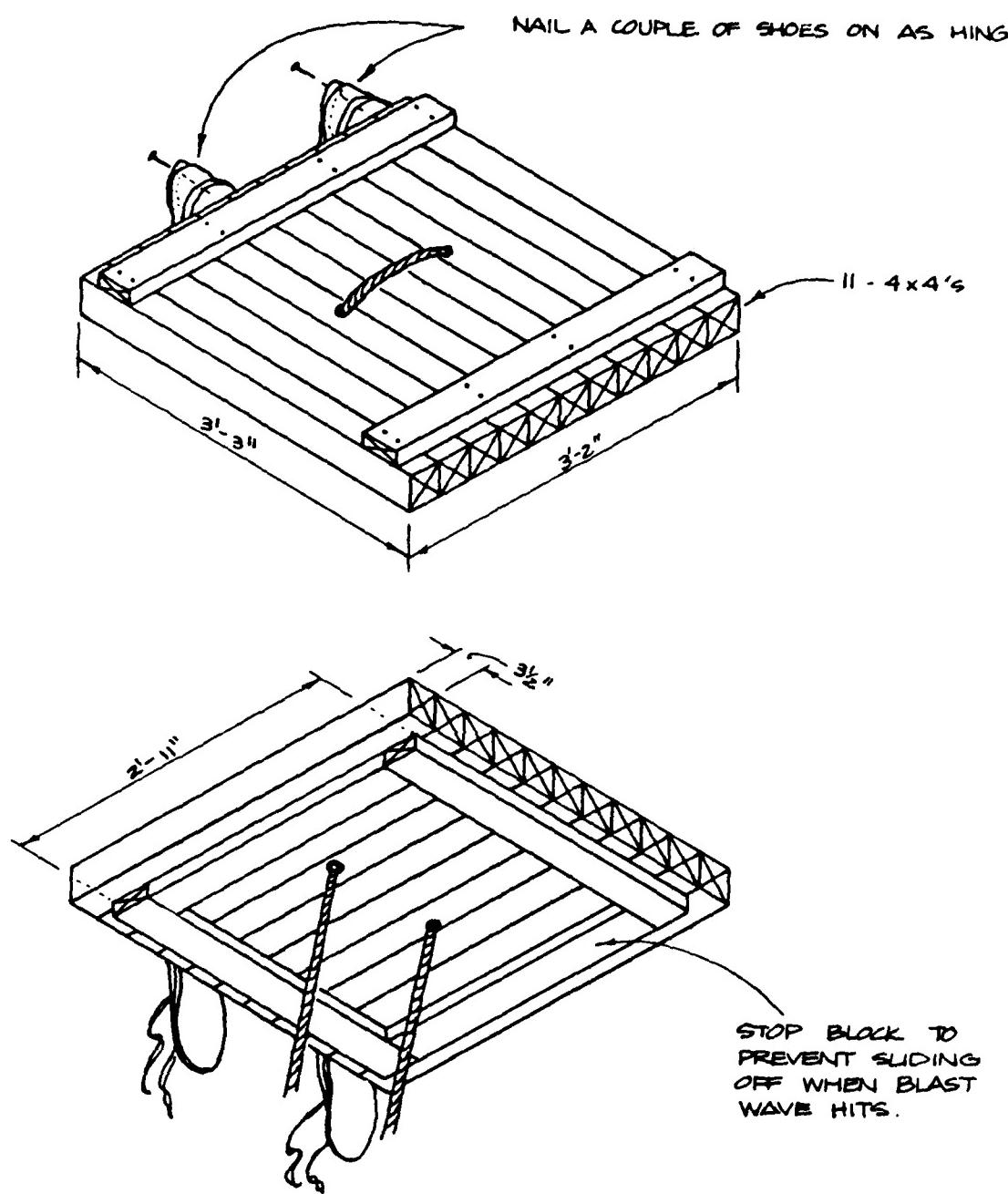


Fig. 9. Closure for 40 psi Entrance Structure to Key Worker Shelter  
(Wood Construction).

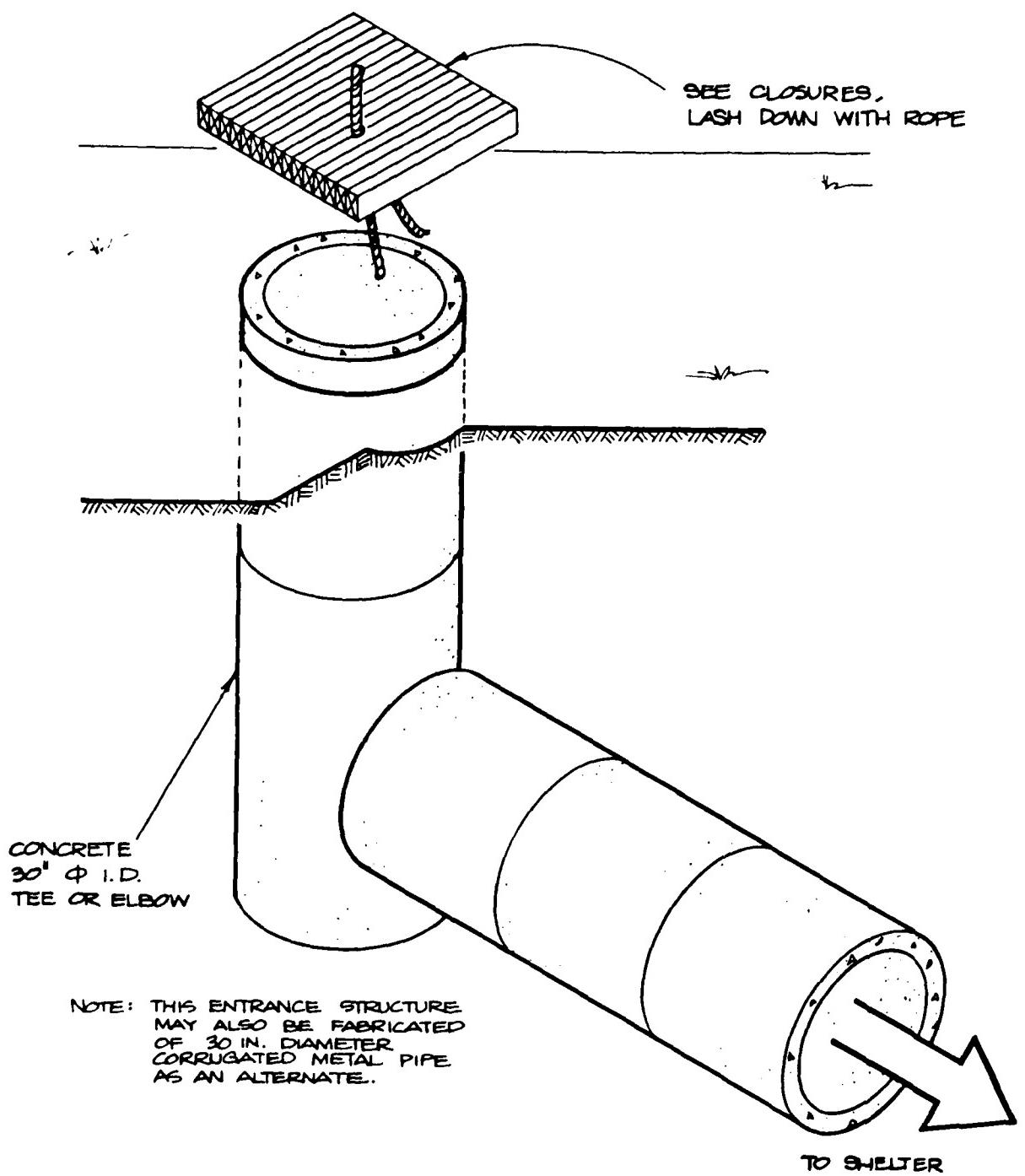


Fig. 10. 40 psi Entrance Structure to Key Worker Shelter (Concrete Pipe Construction).

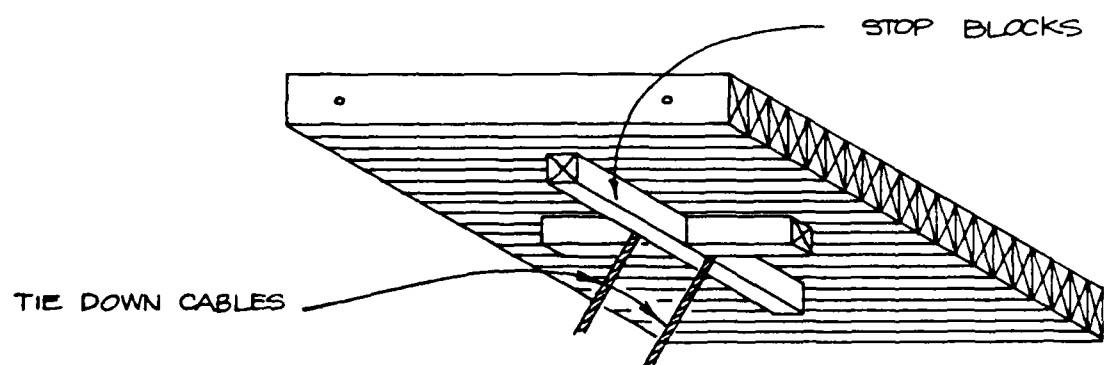
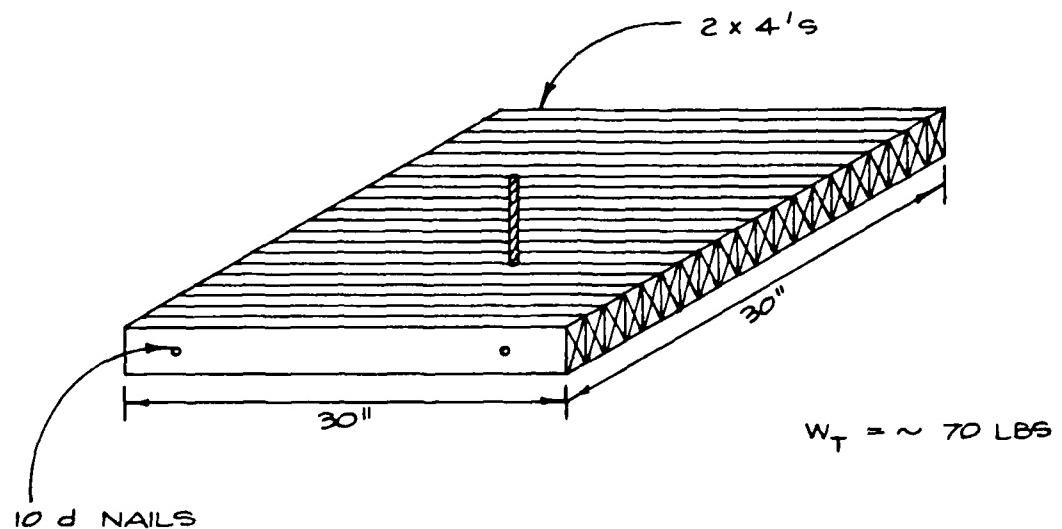


Fig. 11. Expedient Manhole Closure, Key Worker Area.

TABLE 1: CLOSURE MATERIALS

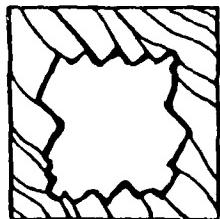
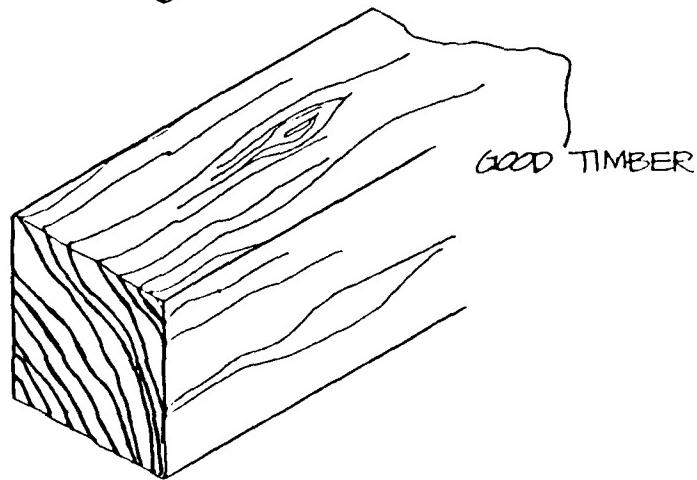
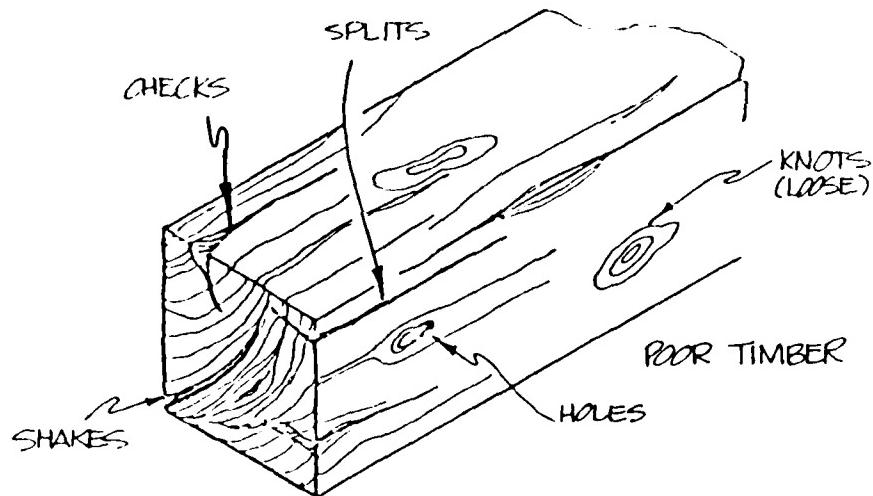
Steel doors	Telephone or power poles
Wood doors (solid)	*Filled sandbags
Toilet doors and partitions	*Filled paper bags
Steel cover plates	*Filled paper boxes
Desk and table tops	*Filled plastic garbage cans
Railroad ties	Brick or concrete block
Plywood	*Filled oil or paper drums
Wood, steel, or concrete fence posts	*filled with sand or earth

The use of wood products for closures requires that material variations affecting wood strength be considered. Wood fence posts, power poles, or railroad ties may be splintered or may exhibit rot or other defects. Generally, poor timber may have checks, shakes, or splits. These features are illustrated in Figure 12.

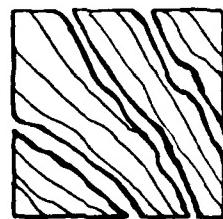
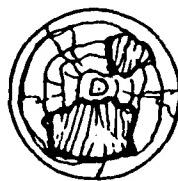
Comparison of various materials that may be used to construct both horizontal and vertical closures is shown in Figure 13. This figure indicates the maximum opening width that may be spanned without intermediate support for various materials. This chart can be used in two ways:

1. Enter the chart with the minimum opening width, and list the type and thickness of materials that could be used for closures. Then, select the most available materials from the list; or --
2. Enter the chart with a known available resource and determine the width of closure that may be accommodated. This alternative will indicate if a further search for closure resources is required.

As an example, assume a basement shelter has two openings -- one vertical opening that is 18 inches in diameter, and the other, a horizontal opening 30 inches by 40 inches. The shortest dimensions are 18 inches and 30 inches, respectively. Entering the chart from the left with these dimensions yields the



ROTTED TIES OR POSTS



SPLINTERED POSTS / POLES / TIES

Fig. 12. Factors Affecting Wood Strength.

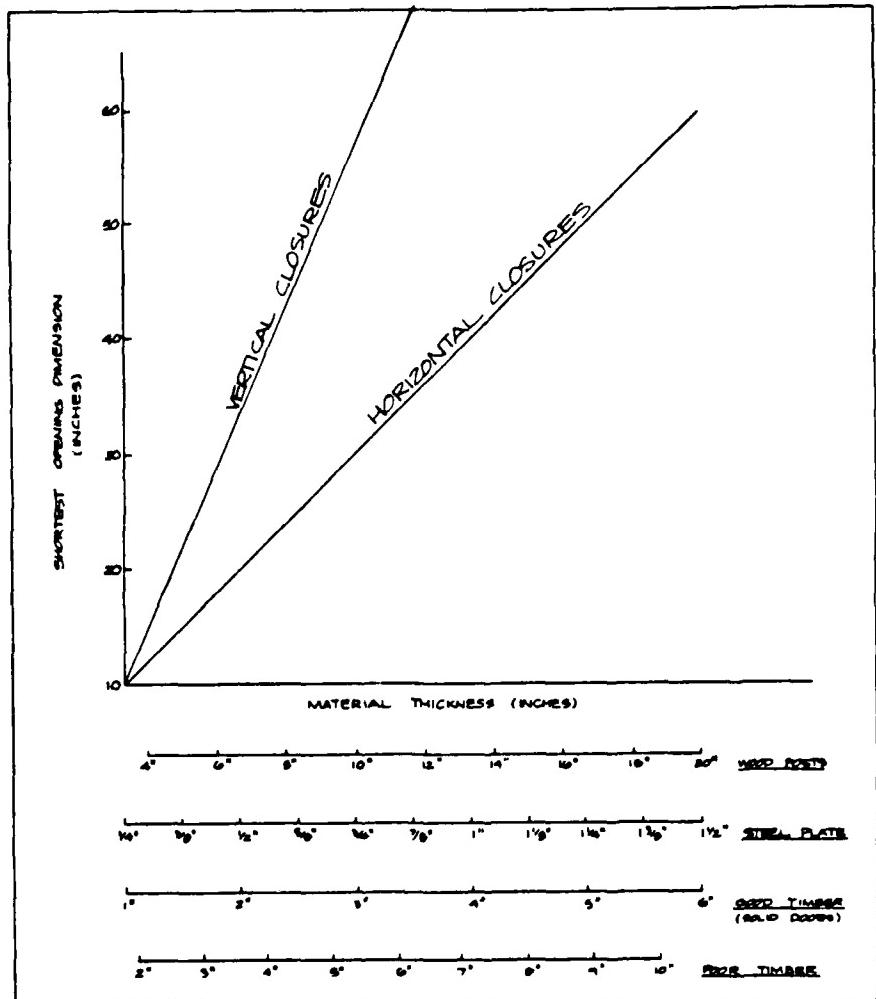


Fig. 13. Material Thickness Required to Close Various Openings (40 psi).

following list of alternative closure materials:

<b>18-inch Diameter</b>	<b>30 inches by 40 inches</b>
4-inch wood post	10-inch wood post
3/8-inch steel plate	3/4-inch steel plate
2-inch timber (good)	3-inch timber (good)
3-inch timber (poor)	6-inch timber (poor)

With these lists, available resources can be compared and determined.

It must be remembered that all shelter closures also require radiation protection. The most straightforward approach is placing earth over the closure if it is horizontal, or piling earth against the closure if it is vertical. The earth placement may require significant personnel time or earth-moving equipment, particularly over basement floors enclosed by structural improvements. One expedient method is to place the earth (or sand) in containers such as sandbags, paper bags, cardboard boxes, or other containers.

Figures 14, 15, and 16 illustrate different types of basement closures and placement of earth radiation protection.

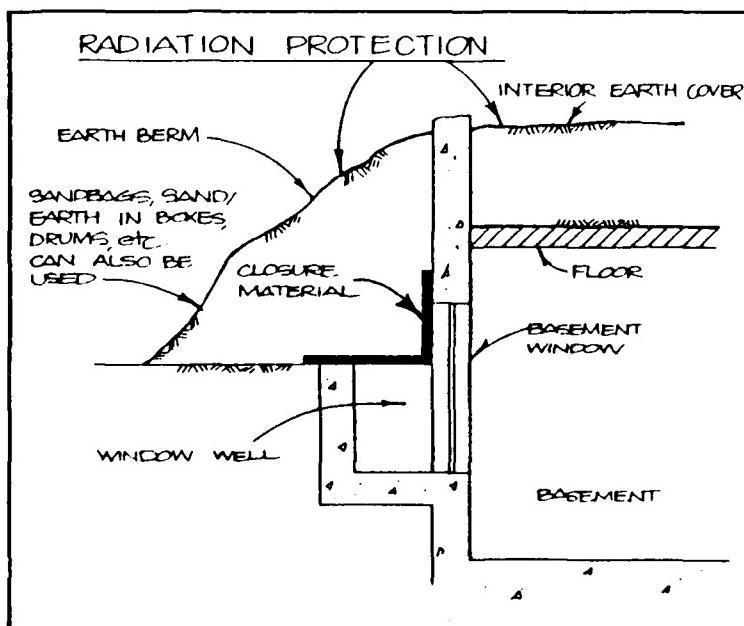
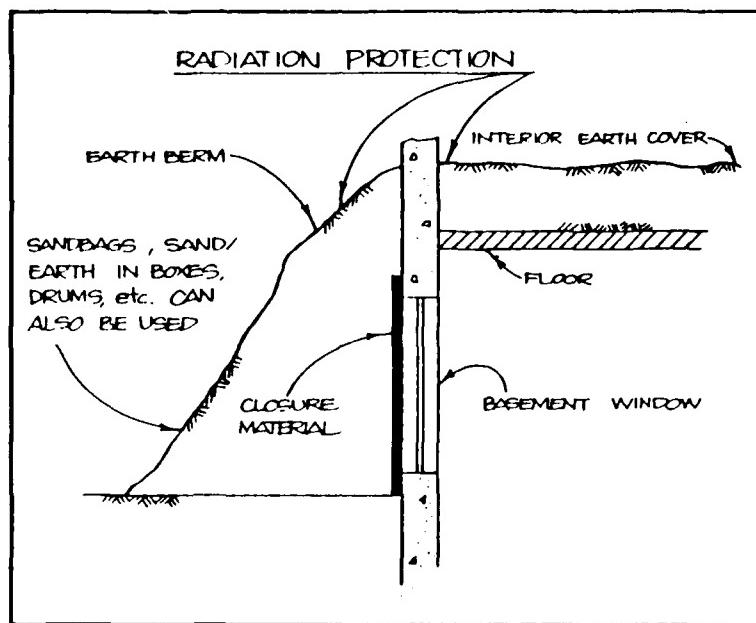


Fig. 14. Window Closures.

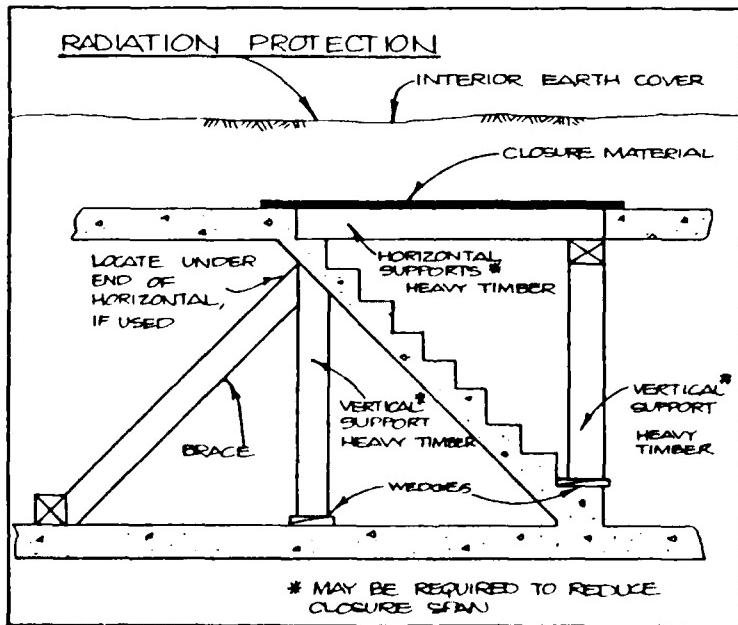
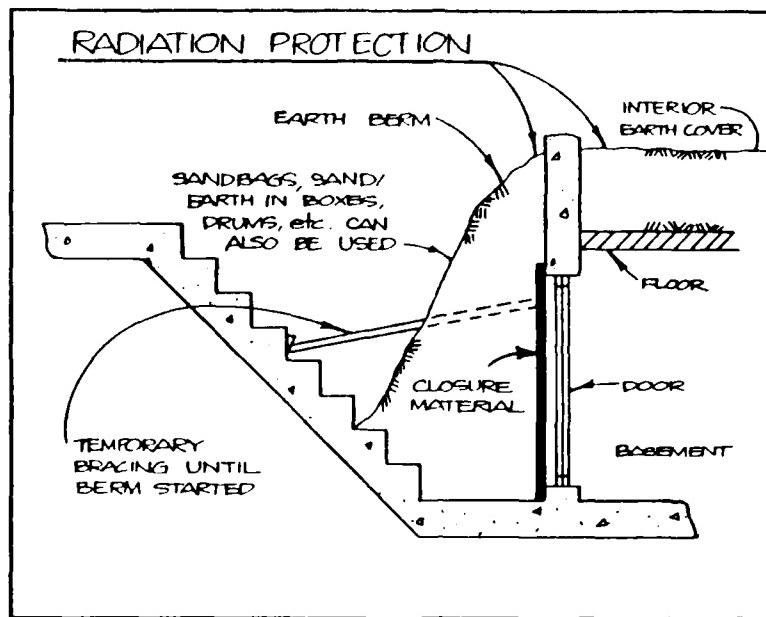


Fig. 15 . Stair and Door Closures.

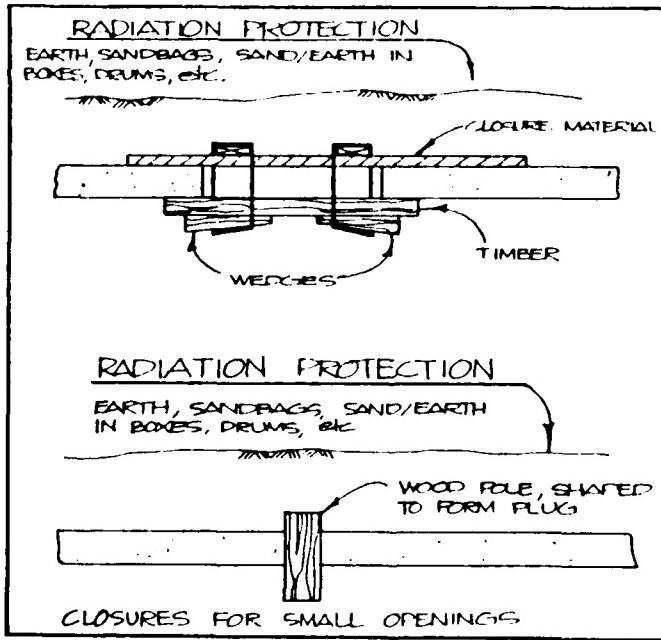
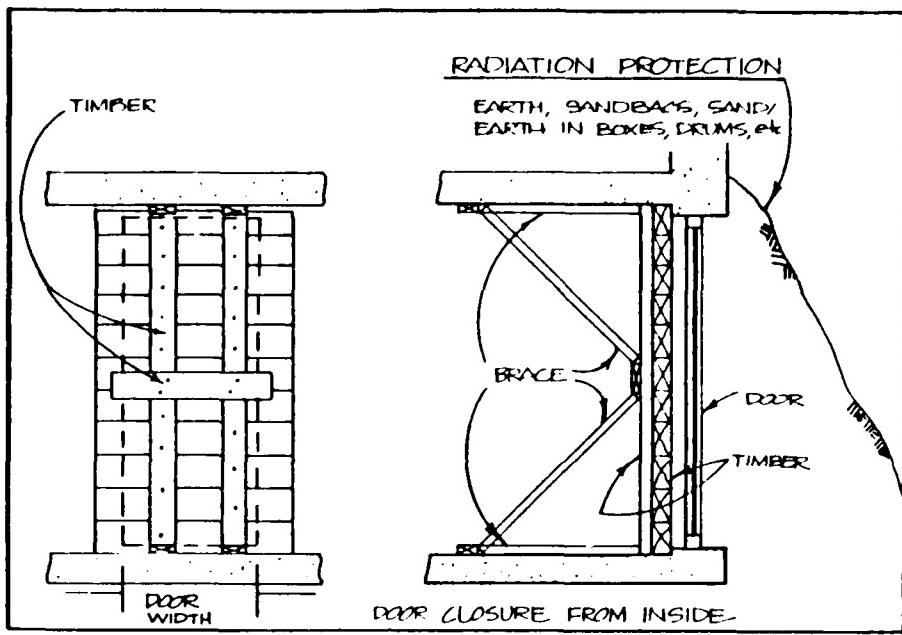


Fig. 16 Door and Small Opening Closures.

#### **STEP 6: Assess Shelter Stocking**

Provision for emergency food, medical, and other supplies must be made, since warning of an impending nuclear attack may not allow for last-minute purchases. Each key worker shelter established for long stay-time should be provided with a minimum of two weeks food and water for each key worker.

Water. -- An adequate water supply is even more important to survival than an adequate food supply. An individual can survive for four weeks without food, but could not survive more than a few days without water or similar fluids. Moreover, tests completed on groups living under shelter conditions have shown that limiting fluids to the amount considered necessary for survival can cause considerable discomfort and is more critical than crowding, heat, or boredom.

The minimum water each individual should be provided for survival is one gallon per day --- one-half gallon for drinking and one-half gallon for other purposes. The water can be stored in containers in the shelter, or connected to an external storage source independent of municipal supply systems.

Food — The most important factors to be considered in providing an adequate food stockpile are nourishment (food value in relation to volume), long shelf life, and ease of preparation. Of less importance are palatability and cost. A balanced diet is not necessary, since the stockpile is intended to be used for only a limited period of time.

Foods that require little space for storage, that keep for months without refrigeration, and that require little or no cooking are best. Cans and jars sized to meet requirements for single meals are best, as some foods deteriorate rapidly after a container is opened. Foods canned in metal or glass will stay in good condition for six or more months if kept in a dry, cool place (preferably, not above 70°F or below freezing). Replace canned foods with a fresh supply at least once a year and foods in paper boxes without added protection at least every three months.

Table 2 lists foods that are best suited for shelter supplies. The table is designed to specify foods necessary under three different stay-times. The quantities shown in the list are sufficient for one adult and supply 2,000 calories per day.

Other Supplies -- In addition to food and water there are a number of other essential supplies that should be stocked in the shelter. The requirements for these items are listed in Table 3 for three shelter stay-times.

An operating battery-powered radio is an essential part of an effective shelter. Since radio reception is cut down by the shielding necessary to keep out radiation, as soon as the shelter is completed a radio reception check must be made. It will probably be necessary to install an outside antenna to receive CONELRAD broadcasts, which are much weaker than normal broadcasts.

Fire extinguishers should be easily accessible and available inside shelters, and should not affect the breathability of the air when used.

Waste Disposal -- If stay-times in shelters exceed 72 hours, all stored garbage and human wastes should be buried under a minimum of 12 inches of earth to discourage insects and animals from disturbing the wastes. Burial should take place when safe shelter emergence is possible.

TABLE 2. REQUIRED WATER AND FOOD SUPPLIES PER KEY WORKER

Food Item	Long Stay-Time up to 2 weeks	Stock per person	Short Stay-Time 24 to 72 hrs	Stock per person	24 hrs or less
				Stock per person *	
<u>Water</u> - Stored in a dark place in clean containers with tightfitting lids. Rinse and refill containers every 3 months.		14 gals	6 qts	4 qts	
<u>Milk</u> - Nonfat, dry Evaporated		20 oz 14 oz	1 cup 3 oz		* For 24 hrs or less, water alone is sufficient.
<u>Juices</u> - Tomato, grape, apple. In crown capped bottles only. Store upright.		64 oz	1½ cup		
<u>Fruit</u> - Applesauce, pears, peaches. In glass jars, glass lids only. Store upright.		112 oz	1½ cup		
<u>Vegetables</u> - Corn, peas, beans, spinach		112 oz	--		
<u>Soups</u> - Canned or dehydrated (in can)		112 oz	1½ cup		
<u>One-Dish Meals</u> - Canned goods including chicken and rice or noodles, pork and beans, baked kidney beans, chile con carne, and beef stew.		208 oz	3 pints		
<u>Spreads</u> - Jam, jelly, marmalade Peanut butter		14 oz 14 oz	-- 3 oz		
<u>Crackers</u> - In glass or cans		56 oz	12 oz		
<u>Beverages</u> - Instant coffee or tea, cocoa		4 oz	--		
<u>Sugar</u>		4 oz	--		
<u>Hard Candies</u>		16 oz	--		
<u>Salt</u>		4 oz	1 oz		
<u>Sterno</u>		4 cans	1 can		

TABLE 3 . KEY WORKER ESSENTIAL SUPPLIES

	Long Stay-Time up to 2 weeks	Stay-Time 24 to 72 hrs	Short Stay-Times 24 hrs or less
<b>Cooking &amp; Serving Equipment:</b>			
Cups	X	X	-
Bottle opener	X	-	-
Plates	X	X	-
Matches	X	X	X
Can opener	X	X	-
Eating utensils	X	X	-
Pocket knife	X	X	X
<b>Clothing &amp; Bedding:</b>			
Towels	X	X	-
Sleeping bags	X	X	-
Spare clothing	X	-	-
<b>Sanitation Supplies:</b>			
Soap	X	X	-
Toilet tissue	X	X	X
Paper towels	X	X	-
Disinfectant (chlorine, bleach)	X	X	-
Insecticide	X	-	-
Garbage can	X	X	-
Human waste can	X	X	-
Emergency toilet	X	X	-
Plastic bags with ties	X	X	X
First aid kit (large)	X	X	-
<b>Tools &amp; Miscellaneous Items:</b>			
Candles	X	X	X
Hammer	X	X	X
Wrench	X	X	-
Bucket	X	X	X
Shovel	X	X	X
Pliers	X	X	-
Screwdriver	X	X	-
Brooms (small)	X	X	-
Batteries	X	X	X
Flashlight	X	X	X
Calendar	X	X	-
Clock or watch	X	X	X
Axe	X	X	-
Crowbar	X	X	X
Emergency generator, fuel oil, & oil with necessary cords, plugs, lights-Hardened to 40 psi	X	X	-
Radio	X	X	X
Radiological monitoring equip- ment	X	X	X

TABLE 3 (contd.). KEY WORKER ESSENTIAL SUPPLIES

	Long Stay-Time up to 2 weeks	Short Stay-Times 24 to 72 hrs	24 hrs or less
<b>Evacuation Supplies:</b>			
Gasoline	X	X	X
Tent	X	X	-
50-mile map of area	X	X	X
Small motorcycle	X	X	X

**STEP 7: Complete the Key Worker Shelter Implementation Analysis**

There will likely not be more than three days available after the evacuation warning in which to implement a key worker shelter. The optimum situation is to implement beforehand, but it has been found possible to implement a short stay-time key worker shelter in one day. To determine feasibility of "last-minute" implementation, advance planning and preparation are required. The attached form provides a quick status or summary report to help prepare a schedule.

CHECKLIST A

SHELTER IMPLEMENTATION

Company Name and Address \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Number of Key Workers Needing Shelter \_\_\_\_\_

1) Is a potential shelter available?

a) Underground basement structure \_\_\_\_\_

b) Existing buried structure - Onsite \_\_\_\_\_

Adjacent off site \_\_\_\_\_

c) New option to be buried: Tank \_\_\_\_\_

Railcar \_\_\_\_\_

Vault \_\_\_\_\_

Other \_\_\_\_\_

2) Transportation to site (Expedient Shelter):

Easily relocated \_\_\_\_\_

Special transportation required \_\_\_\_\_

3) Type of transportation equipment needed:

(a) \_\_\_\_\_

(b) \_\_\_\_\_

4) Space upgrading - Length \_\_\_\_\_ Width \_\_\_\_\_ Height \_\_\_\_\_

a) Type of upgrading - Post & Beam\* \_\_\_\_\_

b) Number of exits, windows, and other passages for closures required?  
\_\_\_\_\_

Dimensions: \_\_\_\_\_ x \_\_\_\_\_

\_\_\_\_\_ x \_\_\_\_\_

\_\_\_\_\_ x \_\_\_\_\_

\_\_\_\_\_ x \_\_\_\_\_

\* Post and beam upgrading of expedient shelters will allow a more efficient use of shelter space.

CHECKLIST A (contd)

c) Ventilation equipment

Is shelter space adequately ventilated? \_\_\_\_\_

Can shelter space be adequately ventilated? \_\_\_\_\_

Are ventilation resources available? \_\_\_\_\_

5) Upgrading resources

a) Are lumber and other materials available for upgrading? Yes \_\_\_\_\_ No \_\_\_\_\_  
Locally? \_\_\_\_\_

b) Are tools and equipment available for upgrading? \_\_\_\_\_  
Locally? \_\_\_\_\_

6) Is burial site available? \_\_\_\_\_

a) Is potential debris pileup a problem? \_\_\_\_\_

b) Is high ground water a problem? \_\_\_\_\_

7) Is secure storage for resources, materials and tools available? \_\_\_\_\_

CHECKLIST B

EXPEDIENT SHELTER STRUCTURE  
IMPLEMENTATION CHECKLIST FOR BURIAL

Expedient shelter has been delivered to key worker plant site for burial.

- (1) Select location for burial away from buildings that may collapse or from facilities that may inundate or damage entry or ventilation equipment.
- (2) Excavate for shelter using:
  - (a) Backhoe
  - (b) Front endloader
  - (c) Crawler tractor
  - (d) Combination of above.
- (3) Excavate for entries - Two are required.
- (4) Provide all modifications to structure for entries and ventilation, and clean structure interior.
- (5) Set structure in excavation with crane or other lift equipment.
- (6) Install entry, ventilation, and closure structures.
- (7) Install interior floor, if required.
- (8) Provide all large shelter stock items prior to backfilling.
- (9) Backfill and berm structure.
- (10) Finish stocking shelter.
- (11) Locate and excavate shelter waste disposal site.

## GLOSSARY AND LIST OF NOTATIONS

- AS BUILT — Structure prior to upgrading
- UPGRADING — Strengthening of a structure to withstand unusual (larger than normal) loads
- HARDENING — Any activity that will reduce vulnerability
- BLAST WAVE — A wave of sudden pressure change that moves outward from an explosion, creating larger than normal loads
- OVERPRESSURE — The sudden pressure change caused by a blast wave, measured in psi. One psi is equivalent to a column of water 2.3 feet high or a column of soil 1.4 feet high
- RISK AREA — Region that is subjected to blast pressures over 2 psi
- HOST AREA — Region that is subjected to blast waves with pressures of 2 psi or less
- KEY WORKER SHELTER — A shelter that will protect the inhabitants to 40 psi or better (equivalent to a column of water 92 feet high, or a column of soil 57 feet high)
- $P_f$  — Protection Factor (radiation). A number that indicates how many times less severe the effect of radiation is in a shelter than that received when there is no protection
- PSF — Pounds per square foot (an indication of pressure loading; a one-foot thick layer of soil would apply a pressure of about 110 psf)
- PSI — Pounds per square inch (144 psf = 1 psi)

**APPENDIX A**

**U P G R A D I N G   D E T A I L S**

## Appendix A

### UPGRADING DETAILS

This appendix supplements the upgrading information described in the manual. Tables A-1 and A-2 are intended to provide additional data and details required for shoring. A number of important facets of upgrading are presented below.

#### Shelter Upgrading Considerations

- o Placement of some shoring systems will be difficult to do manually because of weight problems.

Wood posts larger than 10 inches by 10 inches and longer than 8 feet will weigh more than 200 lb per post.

Nearly all steel post 12 feet in length exceed 200 lb per post; the maximum weights can be 350 lb.

- o Post lengths are limited to 12 feet, since most basement areas are not expected to exceed this height.

- o When using post and beam upgrading methods, **use steel beams only**.

**Wood beams cannot be used for upgrading**, because of crushing of the beam fibers.

Steel beams will require a forklift or other equipment to hoist the beams and hold them in place for placement of the post shores.

- o Details of post shores and post and beam shores are shown in Figs. A-1 and A-2. Additional information is given below.

Steel bearing plates (Fig. A-1) are required on all steel beams where floor loads are transmitted to the beams by tee-beam (Fig. A-2) or one-way joist types of construction. Bearing plates are not required between the beams and hollow-core slabs.

Steel bearing plates should be tack welded to the steel beams/columns as shown in Fig. A-2. Bearing plates should be as wide as the steel beam flanges, and minimum lengths as specified in Table A-2.

Steel shores will require bearing plates welded on both ends of the shore.

The length of the steel shore should be carefully measured and cut with bearing plate thickness allowance considered. Total length should allow for placement of wedges to provide a tight fit.

All posts will need to be placed in vertical position, moved laterally into place, and held vertically until wedges are placed.

Steel post shores require steel wedges, and wood post shores require wood wedges. Two wedges are required at each shore in order to provide a tight fit and assure uniform bearing.

TABLE A-1: SHORE DESIGNATION

STRUCTURAL TYPE AND DIMENSIONS  ↓ SHORE SPACING →	MAXIMUM SHORE LENGTH - FEET				
	TYPE A		TYPE B		TYPE C
	A1	A2	B1	B2	C1
WOOD POST (NOM.)	* to 4' x 4'	4' x 4' + 5' x 5'	5' x 5' + to 6' x 6'	6' x 6' + to 7' x 7'	7' x 7' + to 8' x 8'
6" x 6" 6" x 8" 8" x 8" 8" x 10" 10" x 10" 12" x 12"	8' 9' 14'	7' 11' 12'	10'	12'	12'
STEEL PIPE		8' 12'	12'	12'	8'
STANDARD STRENGTH 4" x 0.237" 5" x 0.258" 6" x 0.280" 8" x 0.322"					
EXTRA STRONG 3½" x 0.318" 4" x 0.337" 5" x 0.375" 6" x 0.432"	10' 12'	12'	12'	12'	
DOUBLE EXTRA STRONG 3" x 0.600" 4" x 0.674" 5" x 0.750"	10'	12'	10'	12'	
STRUCTURAL STEEL TUBE 4" x 4" x 3/16" 4" x 4" x 1/4" 4" x 4" x 5/16" 4" x 4" x 3/8" 4" x 4" x 1/2"	10' 12' 12' 12' 12'	8'	10'	8'	
5" x 5" x 3/16" 5" x 5" x 1/4" 5" x 5" x 5/16" 5" x 5" x 3/8" 5" x 5" x 1/2"	12'	12' 12'	8' 12'	12'	10'

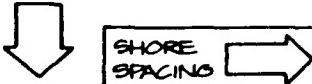
\*minimum shore spacing should not be less than 30° (2.5') on centers under most austere conditions.

TABLE A-1: SHORE DESIGNATION (contd)

STRUCTURAL TYPE AND DIMENSIONS	MAXIMUM SHORE LENGTH - FEET				
	TYPE A		TYPE B		TYPE C
	A1	A2	B1	B2	C1
 Shore Spacing 	* to 4' x 4'	4' x 4' + to 5' x 5'	5' x 5' + to 6' x 6'	6' x 6' + to 7' x 7'	7' x 7' + to 8' x 8'
STRUCTURAL STEEL TUBE (cont.)			12'	10'	
6" x 6" x 3/16"			12'	12'	
6" x 6" x 1/4"			12'	12'	
6" x 6" x 5/16"			12'	12'	
6" x 6" x 3/8"				12'	
6" x 6" x 1/2"					10'
7" x 7" x 3/16"			12'	8'	
7" x 7" x 1/4"				12'	
7" x 7" x 5/16"					12'
8" x 8" x 1/4"					12'
4" x 3" x 5/16" 		8'			
5" x 3" x 3/16"		8'			
5" x 3" x 1/4"		10'			
5" x 3" x 5/16"		10'			
5" x 3" x 3/8"		10'	8'		
5" x 3" x 1/2"		12'	8'		
6" x 3" x 3/16"		8'			
6" x 3" x 1/4"		10'			
6" x 3" x 5/16"			8'		
6" x 3" x 3/8"		12'	10'		
6" x 4" x 3/16"		12'			
6" x 4" x 1/4"		12'	10'		
6" x 4" x 5/16"			12'	8'	
6" x 4" x 3/8"				10'	
6" x 4" x 1/2"				12'	8'

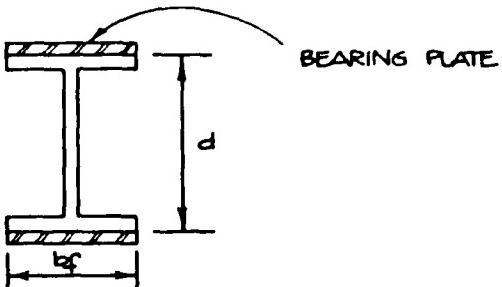
\* minimum shore spacing should not be less than 30" (2.5') on center under most austere conditions.

TABLE A-1: SHORE DESIGNATION (contd)

STRUCTURAL TYPE AND DIMENSIONS	MAXIMUM SHORE LENGTH - FEET				
	TYPE A		TYPE B		TYPE C
	A1	A2	B1	B2	C1
	* to 4' x 4'	4' x 4' to 5' x 5'	5' x 5' to 6' x 6'	6' x 6' to 7' x 7'	7' x 7' to 8' x 8'
<b>STRUCTURAL STEEL TUBE</b> <i>(cont.)</i>					
7" x 5" x $\frac{3}{16}$ "		12'			
7" x 5" x $\frac{1}{4}$ "		12'	10'		
7" x 5" x $\frac{5}{16}$ "			12'		
7" x 5" x $\frac{3}{8}$ "			12'	10'	
8" x 4" x $\frac{1}{4}$ "		12'	8'		
8" x 4" x $\frac{5}{16}$ "			12'		
8" x 4" x $\frac{3}{8}$ "			12'	8'	
8" x 6" x $\frac{1}{4}$ "			12'		
8" x 6" x $\frac{5}{16}$ "				12'	
<b>STEEL WIDE FLANGE BEAMS</b>					
MS-18.9 5" wide by 5" deep	12'	8'			
W6-20 6" wide by 6" deep	12'	10'			
W5-16 5" wide by 5" deep	12'				
W5-14 5" wide by $5\frac{1}{8}$ " deep	12'	8'			
W6-16 4" wide by $6\frac{1}{4}$ " deep	8'				
W6-15 6" wide by 6" deep	12'				
W6-20 6" wide by $6\frac{1}{4}$ " deep	12'	10'			
W6-25 $6\frac{1}{2}$ " wide by $6\frac{3}{8}$ " deep		12'	8'		
W6-24 $6\frac{1}{2}$ " wide by $7\frac{3}{8}$ " deep		12'	8'		
W6-28 $6\frac{1}{2}$ " wide by 8" deep			12'		

\* minimum shore spacing should not be less than 30° (2.5') on centers under most austere conditions.

TABLE A-2: BEAM REQUIREMENTS, POST AND BEAM SHORING



SHORE CLASS (FROM MAIN TEXT)	STEEL BEAM DESIGNATION	LIMITING BEAM DIMENSIONS			LENGTH (INCHES) OF BEARING PLATE (MINIMUM)	
		BEAM DEPTH - INCHES		MINIMUM BEAM FLANGE WIDTH INCHES $b_f$		
		MINIMUM d	MAXIMUM d			
<b>TYPE A</b>						
A1	WB x 35	8 1/8	9	8	6 1/2	
A1	W10 x 33	9 3/4	11 3/8	8	8 1/2	
A1	W12 x 27	12	14 3/8	6 1/2	7	
A1	W14 x 26*	13 7/8	14 3/4	5	5 1/2	
A1	W16 x 26	15 5/8	16 3/8	5 1/2	5 3/4	
A2	W10 x 60	10 1/4	11 3/8	10 1/8	7 3/4	
A2	W12 x 50	12 1/4	13 3/8	8 1/8	8 3/4	
A2	W14 x 43	13 5/8	14 3/4	8	11 1/2	
A2	W16 x 40*	16	16 3/8	7	11 1/2	
A2	W18 x 40	17 7/8	18 1/2	6	11 1/4	
<b>TYPE B</b>						
B1	W12 x 84	12 1/2	14 3/8	12 1/8	9 1/4	
B1	W14 x 74	14 1/4	14 3/4	10 1/8	10 1/2	
B1	W16 x 71	16 1/8	16 3/8	8 1/2	9 1/2	
B1	W18 x 60	18 1/4	18 1/2	7 1/2	12	
B1	W21 x 55*	20 3/4	21 1/2	8 1/4	13 3/4	
B1	W24 x 55	23 1/2	24 3/4	7	12 3/4	
B2	W18 x 960	18 1/8	19 1/2	11 3/4	13 1/4	
B2	W21 x 960	21 1/8	21 1/2	9	11	
B2	W24 x 760*	23 7/8	24 3/4	9	10	
B2	W27 x 84	26 3/4	27 1/4	10	15	
<b>TYPE C</b>						
C1	W21 x 127	21 1/4	21 1/2	13	14 3/4	
C1	W24 x 110	24 1/8	24 3/4	12	17 3/4	
C1	W27 x 102	27 1/8	27 1/4	10	17 1/2	
C1	W30 x 99*	29 7/8	30 3/8	10 1/2	17 3/4	

\* optimum section based on weight per foot.

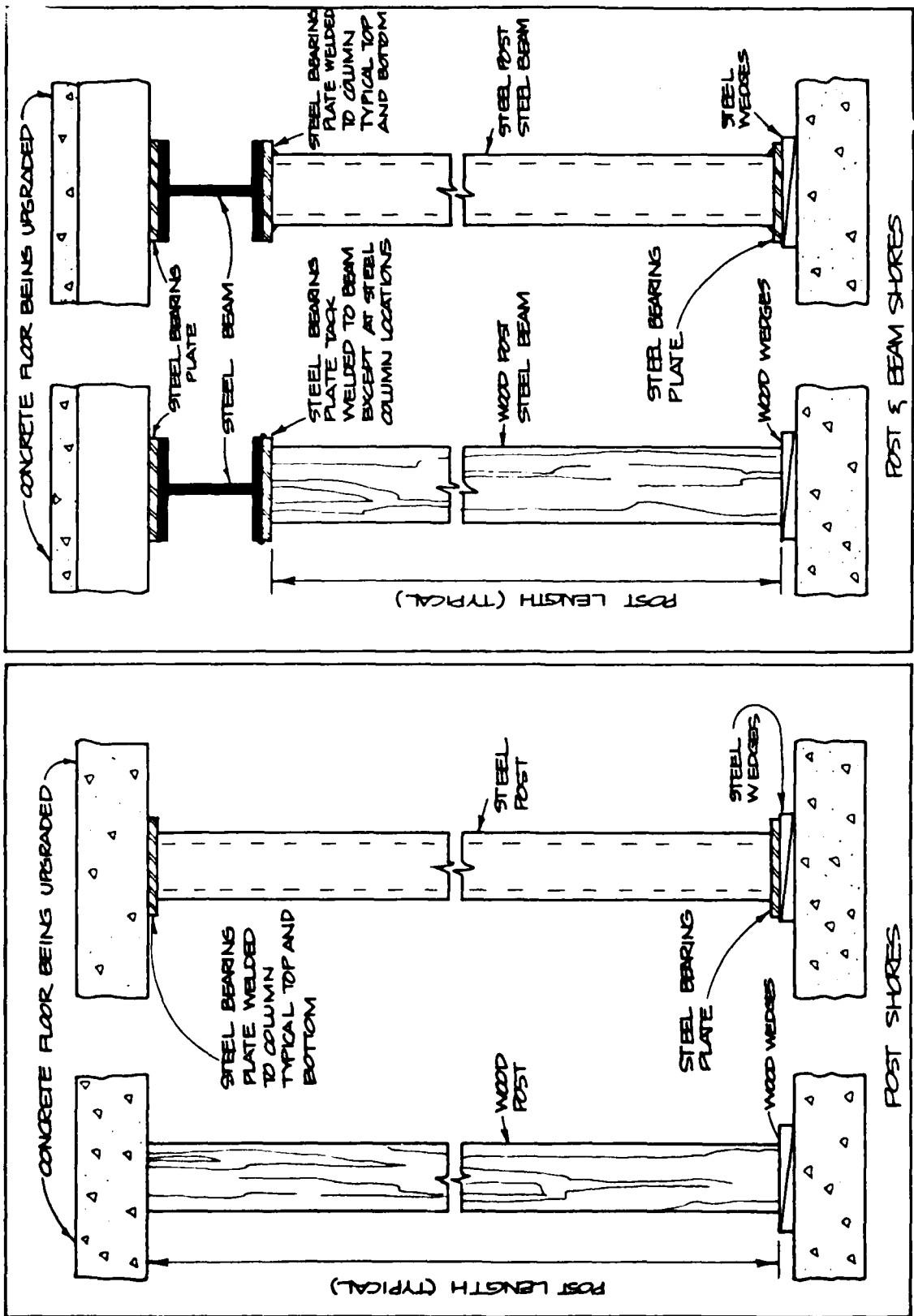
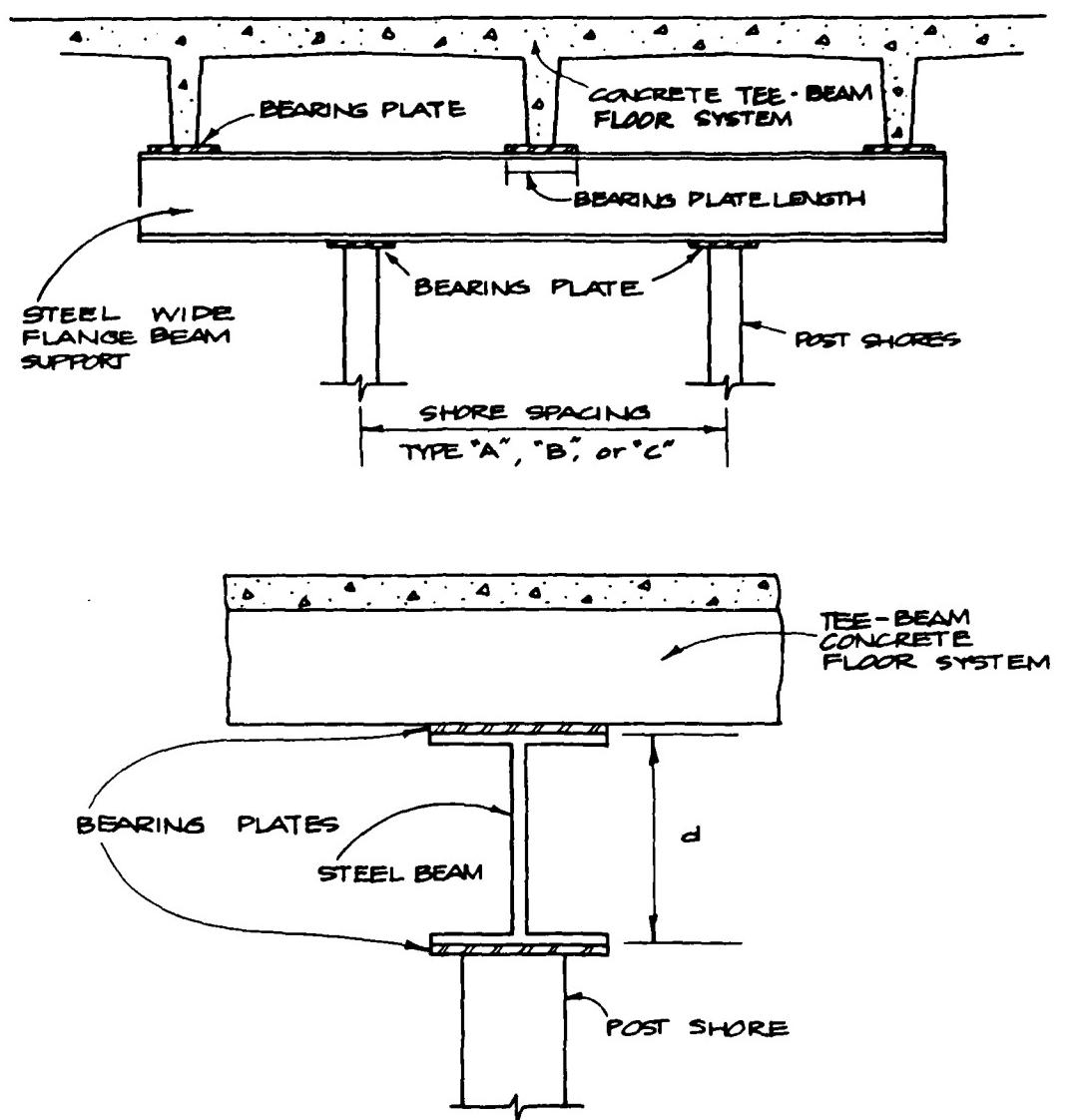


Fig. A-1. Post Shore Details.



NOTE: BEARING PLATES MUST BE USED BETWEEN BEAM AND SUPPORTED FLOOR MEMBERS ABOVE, AND AT BOTH ENDS OF POST SHORES.

Fig. A-2. Post and Beam Shoring System Details.

RESOURCE LISTRequiredQuantity

1. Posts, steel or wood
2. Beams, steel
3. Nails
4. Hammer
5. Saw
6. Wedges
7. Tape measure/yardstick, etc.
- 8.
- 9.
- 10.

**POSTS**

**RESOURCE LIST**

<u>Required</u>	<u>Quantity</u>	<u>Available</u>
1. Posts, steel or wood	_____	_____
2. Nails	_____	_____
3. Hammer	_____	_____
4. Saw	_____	_____
5. Wedges	_____	_____
6. Tape measure/yardstick, etc.	_____	_____
7.	_____	_____
8.	_____	_____
9.	_____	_____
10.	_____	_____

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**SUPPLEMENTARY**

**INFORMATION**

**SCIENTIFIC SERVICE, INC.**

517 E. BAYSHORE, REDWOOD CITY, CA 94063 TELEPHONE: (415)368-2931

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**INDUSTRIAL PROTECTION MANUAL, SSI Report No. 8011,  
prepared for Federal Emergency Management Agency under  
Contract No. EMW-C-0154, Work Unit 1124E, June 1981.**

**AD Number: A 102631**

The attached sheets are to replace two pages in Booklet 10 of the above referenced Industrial Protection Manual, which was distributed in July 1981.

The replacement material is intended to clarify the application of Figure 13 to the selection of appropriate closures for superfluous openings in below-grade expedient shelters and accessways in shelter entry structures.

## **STEP 5: Assess Shelter Closures and Access Alternatives**

Whenever adapting or converting existing structures to key worker shelter space, closures will generally be required for existing openings. Shelters will need to be below ground to provide the blast and radiation protection required at 40 psi.

Closures will serve two purposes, to seal superfluous openings and to protect accessways. For superfluous openings, such closures may be oriented anywhere from horizontal to vertical, and to seal out radiation (as well as blast) several feet of earth cover, or an equivalent substitute, will be required. To provide accessways, special blast and radiation resistant shelter entry structures will be required.

### **Shelter Entry Structures**

At 40 psi, special shelter entry structures are required to provide blast and radiation protection that existing entries cannot. Because of the nature of airblast waves when reflected directly off vertical surfaces, accessway closures must either be flush with a horizontal section of the ground surface, be a part of a vertical area that is small in extent (e.g., as in the shelters at the tops of pages 26 through 28 - perhaps 9 feet high and 18 feet across the base), or be sufficient to resist a peak (reflected) overpressure of 146 psi if installed in the face of a structure or cliff that is extensive (i.e., tens of feet high and across).

Suitable entry structures of wood, and of concrete or corrugated metal pipe, and closures for expedient shelter accessways, are shown in Figures 8 through 11. Note these particular entryway structures are designed to be below ground and the entryway closures to be flush with the horizontal surface.

### **Non-accessway Closures**

Any basement structure (or expedient shelter) to be upgraded may have a stairway, windows, doors, ventilation ducts or other openings that must be rendered blast and radiation proof. These openings can be bridged using a variety of readily available materials (e.g., wood, steel), then covered with earth for radiation protection. Examples of wood materials that may be used are fence posts, spare power poles (cut up), railroad ties, solid core doors, and wood beam and plank pieces. Steel plate and rolled beam sections, though less readily available, may also be used. Table 1 (page 44) lists materials that may be considered as alternatives for closures.

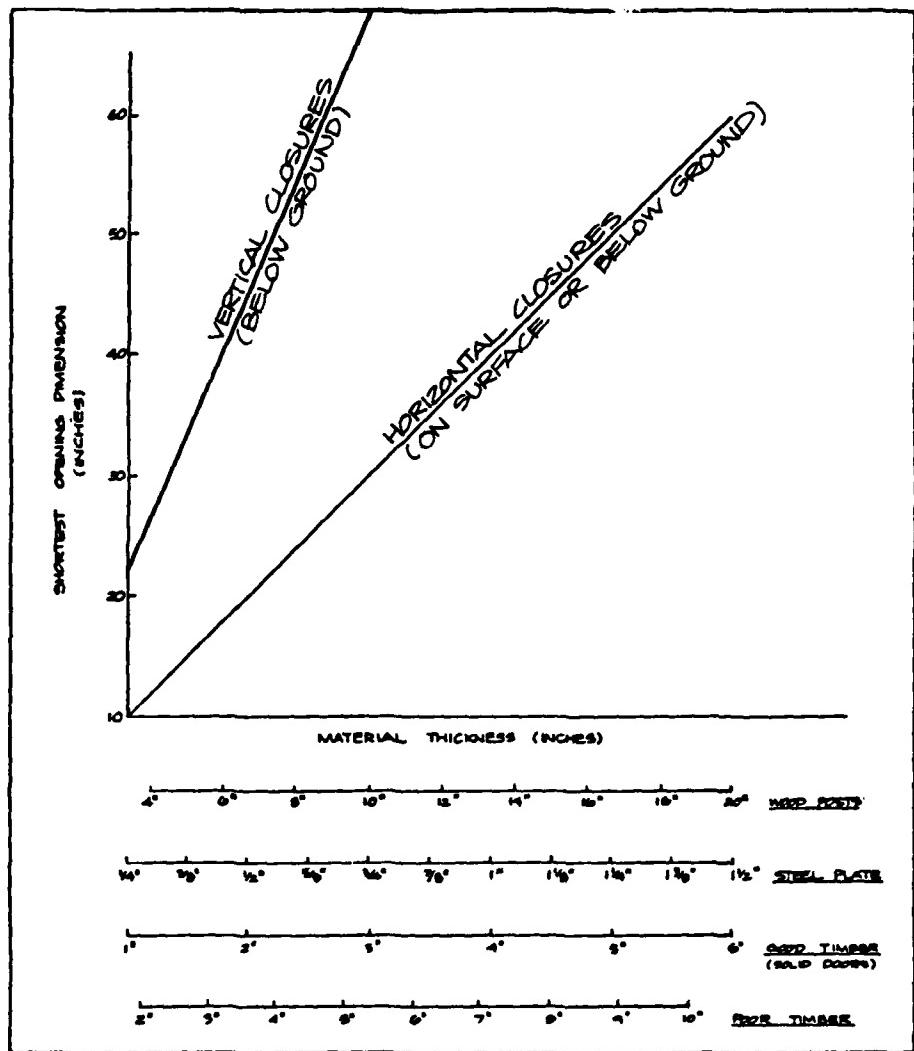


Fig. 13. Material Thickness Required to Close Various Openings (at the 40 psi ground range).